

FAO ANIMAL PRODUCTION AND HEALTH PAPER 52

Small-scale sausage production

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P R E F A C E

Meat is an extremely complex raw material in which a single factor results in a series of interrelated changes and processes. Throughout many varying and intricate operations, an ingenious sausage maker, skilled in his task, has to stimulate those desired

structural and chemical changes and processes which lead to conversion of raw meat into a final sausage product that his customers want.

Although sausage manufacture has had a long and colourful history, developments over the past few decades have led to process affording a wide variety of new sausage products, including new types of frankfurters, salamis, etc. Several recent developments have been possible only because of the processing knowledge gained over many years' experience in traditional small-scale sausage manufacture. Probably the most significant development has been in the field of meat science and biochemistry, which established a close liaison between the traditional sausage-making art and modern industrial processing. This liaison has since led to notable advances in the introduction of new types of machines in the application of new chemical additives, new types of casings, packaging materials, etc. Simultaneously, there have also been changes in the concepts of

basic procedures and processes used in sausage manufacture.

Although the size and scope of sausage manufacture have undergone a tremendous metamorphosis in recent years, the rationale behind today's small-scale sausage production and traditional practices remains the same, namely, obtaining a product of high organoleptical value and longer shelf life. There is every reason to believe that still greater rewards can be expected if further developments will be based on the sound experience of traditional sausage-making practices.

Consequently, this manual will describe processing of different groups of sausages in terms of technological interdependence between modern knowledge and traditional techniques and experience.

In the text the emphasis is placed upon the basic techniques and knowledge that govern the operations of sausage manufacture. A special part is devoted to the layout and equipment for sausage

plants. In small-scale sausage production there is a high degree of local variation both in the manner of spicing and the types of sausages demanded and it is for this reason that properties of different meats, the use of spices and types of casings are especially considered. The formulations and processing methods used in the production of conventional and novel sausages, including all-beef products, are also presented with special care. Factors affecting the quality and storage of sausages are described for each individual group but keeping quality problems from the standpoint of sausage distribution are further discussed in the last chapter.

The manual has been written in such way to be of use to those new to sausage manufacture as well as to established meat processors who often need specific information when projecting future plants.

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INTRODUCTION

Sausages are products in which fresh comminuted meats are modified by various processing methods to yield desirable organoleptic and keeping properties. Sausages are one of the oldest forms of meat processing and modern sausage technology has its roots deeply embedded in history.

DEVELOPMENT OF SAUSAGE MANUFACTURE

How and when the first sausage was produced is not known since sausage manufacture antedates recorded history. There are numerous documents testifying that ancient civilizations made and consumed sausages some thousands of years ago. The Romans made “circelli”, “tomacinae”, “butuli” and other types of delicious sausage products which were eaten during

annual orgiastic festivals and sacrifices. Sausages made of tripe and other by-products were particularly consumed by the poorer classes of the Roman population. The early Christian Church prohibited the eating of sausages in Rome for many years.



Fig. 1 CUTS OF BEEF CARCASSES IN ANCIENT EGYPT

(Photo taken by *Dr A. Sedky*, FAO expert at a temple in Luxor, Valley of the Kings, Egypt)

People in the middle ages also consumed many sausages. It is interesting to note that various types of sausages have been produced in an unbroken line through the years in different localities under the climatic and social conditions of various geographical areas. Thus, many sausages popular today were renowned throughout the world many centuries ago.

Refrigeration has played a major role in the development of sausage manufacture. Before the advent of mechanical refrigeration, sausage manufacturing plants were located in the vicinity of the city slaughterhouse, preferably not far from the market, so that both highly perishable meat raw materials and final sausage products were able to move quickly. With refrigeration, sausage manufacture has changed and different types and forms of sausages have been introduced. New trends

and tastes in markets throughout the world are continually creating new demands for sausage manufacture and product changes.

While in Europe and North America the higher prices of beef and years of tradition have favoured pork sausage manufacture, the plentiful supply of low price beef and food habits in many developing countries have justified fresh beef consumption and processing. It would be a misconception to believe that people living in warm climates are not sausage consumers. Nearly all meat consumers in the warm regions of the world produce either typical sausages, stuffed in casings or wrapped in leaves, or, more often, many types of comminuted colourfully seasoned sausage-like products, enjoyed especially in the evening or during various festive periods; the latter, usually beef, mutton or fish products, can sometimes be very popular.

In some parts of the world, the production of sausages is

complicated by religious or sentimental considerations and habits. In certain parts of southeast Asia cattle slaughter is not allowed, in other regions of Asia or in some areas of Africa, pigs are not killed, and occasionally, in many developing countries some people do not consume certain parts or organs of the slaughtered animals. Other problems arise with the production and consumption of meat, including sausages, in warm climatic regions which differ from those encountered in the temperate zones.

Although sausage manufacture in the developing world presents many specific problems, there are untapped opportunities for profitable sausage manufacture in all parts of Latin America, Africa and Asia. These opportunities are especially high where important meat resources are locally available and where extended livestock production offers excellent raw materials for processing.

CHANGING PATTERN OF SAUSAGE TECHNOLOGY

Although sausage technology involving varietal differences, chemical composition, microbiology and processing methods has developed more in the last twenty years than in the previous 3000 years, many technical details in modern sausage production have still remained an art. This is especially true for small-scale production. However, particularly in the sausage producing segment of the meat industry, many aspects of modern meat technology, combined with traditional meat processing practices, are applied. Therefore, it is possible to say that sausage production today is in a permanent evolutionary phase and new changes, based on new technological advances, are continuously in sight.

In the last decade, a large number of innovations and improvements have been developed in the field of sausage manufacture. Apart from mechanization and automatization

trends and other advances in large-scale sausage production, considerable innovations in the small batch type of operations and processes have also been made. Development of new types of sausages from meats other than beef, pork or mutton, particularly from poultry meat, also shows considerable promise. Every change made by sausage manufacturers, from ingredients to processing, has the potential of requiring a series of related changes in sausage formulation, seasoning, etc.

Development of new sausage products.

A need for development of innovative and unique high quality sausage products using the greatest possible efficiency, experience and new knowledge is permanently present in all segments of the sausage manufacturing field. The small sausage manufacturer in particular is facing competition from precooked convenience meat food items and other meat meal products. The goal of the small manufacturer is to increase growth and hold his

market share of customers. This goal can be achieved by continued development of new value-added sausage products and by taking advantage of present processing equipment and knowledge.

A value-added sausage utilizes one or more low-cost raw material in combination with other ingredients to create a sausage which can be sold at a higher price. An example of a value-added sausage product are frankfurters. Frankfurters utilize both low-value trimmings and even by-products, combined with adequate technological knowledge, to create a higher-value sausage.

The custom fit of a new sausage formula into sausage plant production often requires modification of the original formula. Versatility in the usual sausage processing line can create not only one but several new products for the market. For example, a simple grind-mix-grind system with a stuffer not only produces a fresh sausage but also a variety of other products.

The quality aspects of a new product determine the product's continued success. A new sausage product must be delicious in flavour and exhibit a desirable texture. Visually poor-looking products do not attract customers. Especially in warm climates, the shelf life of a product determines whether an initial purchase will be made. Certain modifications are required according to geographical area, such as hot or mild seasoning or the product's physical appearance, etc. Briefly, excellent quality in new sausage items is a must and this can be accomplished without high-cost materials.

The time is past when a sausage manufacturer drew up his own sausage formulation independently and meat and other ingredient suppliers were only required to meet them. Today the development of a sausage specification starts while a new product is still in the planning stages. The specification then remains open to adjustments on a continuing basis to adapt to changes in both the meat and other raw material supply. Through

careful raw material and product quality control, the sausage manufacturer can adjust to these changes by blending raw materials to achieve consistent quality of his finished products.

Some peculiarities of sausage plant management.

While the slaughterman in a sequence of operations disassembles the killed animal, removing all organs and tissues and the butcher, through cutting and boning, still further reduces the size of the meat pieces, the sausage manufacturer, on the contrary, in a series of successive specialized operations fits together the different meat and nonmeat components, converting them into a new product. This fact influences by far the character and nature of the sausage manufacturing process, its organization and management. Whoever plans to be associated with sausage manufacture must master these specialized operations, have a basic technical knowledge and be prepared to apply these in the everyday practice of a quickly changing

developing world.

The ownership of a slaughterhouse, its vicinity and organization also influence the management of a sausage plant in several ways. Firstly, the sausage manufacturer may slaughter his own animals and pay a certain fee to the slaughterhouse authority; the maintenance of a hygienic standard remains the duty of the authority. Secondly, where there is a large throughput, the sausage manufacturer collects only the dressed carcasses and some by-products and transfers them from the slaughterhouse to his processing plant. Thirdly, the sausage manufacturer may be the owner of the slaughterhouse which is specifically designed for the sausage plant. Other numerous situations are also possible which cannot be foreseen with accuracy.

Sausage production makes up that important segment of the complex meat industry field which converts the raw material of a slaughtered animal into meat products of a higher value. With

sausage manufacturing techniques the animal by-products are also revalorized, thus contributing to economic and social development. The sausage manufacturer distributes his products to retailers, restaurants, hotels, etc. or sells them directly to consumers. Therefore, in small-scale sausage production, there is no clear distinction between where production ends and where marketing begins.

The sausage plant layout, described in the following chapter, has primarily been designed to meet the requirements of small-scale production with limited sales. Layouts for larger plants required to serve larger areas must allow not only more room for meat storage and for dealing with larger amounts of other raw materials but also for the more sophisticated technology and organization needed.

Meat processing and meat consumption differ widely between countries and regions. The type of sausage plant and type of

sausage product that can be recommended for one region may involve too large an investment or be totally or partly inapplicable in many other regions. This is the reason why inevitably there will be circumstances under which some of the technological suggestions or methods, given in the following chapters, will seem out of place. The formulations given are intended to indicate some of the specific raw materials, their rations and the techniques applied, which will frequently be found useful, but not to present specific formulae for application in all cases. The sausage manufacturer should select what appears suitable and advantageous for the solution of his own particular problem and apply it with modifications appropriate to the conditions under which he is operating.

CLASSIFICATION OF SAUSAGES

Sausages are usually defined as comminuted seasoned meats, stuffed into casings; they may be smoked, cured, fermented and

heated. They are made from any edible part of the slaughtered, veterinary-inspected animal, and a series of nonmeat ingredients. Good sausages cannot be made from inferior or unsatisfactory raw material. A sausage formulation is always a compromise between the expected quality of the finished product, the cost of raw materials and the techniques applied. The production of a wide variety of sausages is possible through the manipulation of different variables such as meat formulation, processing temperature, types of casing and particle size. By altering certain processing treatments, changes occur within the product's texture and flavour, moisture content, percentage of yield and other attributes. The number and variety of sausages are limited only by the manufacturer's imagination and knowledge.

The meat or spice formula cannot be used for purposes of sausage classification because many sausage formulations include similar combinations of different meats and seasonings. Moreover, the proportions of the various meat types and spices

used vary periodically due to seasonality in raw material supply.

In spite of their multiple varieties, sausages may be roughly divided into two general groups: raw sausages and heat processed sausages. According to the methods applied in their manufacture, raw sausages may further be subdivided into two categories: fresh sausages and fermented sausages. Similarly, heat processed sausages are classified in smoked precooked sausages, emulsion-type sausages and cooked sausages.

- a. Fresh sausages are made from fresh meats which are, as a rule, neither cured, smoked, fermented nor cooked. Fresh sausages must be kept under refrigeration prior to eating. They are heated by the consumer himself before serving.**
- b. Fermented sausages are made from cured or uncured, fermented and often smoked meats but they are not heat processed in any way; they are divided into semidry and dry**

sausages.

- c. Smoked precooked sausages are mostly cured, nonfermented products; their shelf life is increased by heating due to partial reduction of their moisture content; they are usually finally cooked before consumption.**

- d. Emulsion-type sausages comprise ready-to-eat products made from comminuted and well-homogenized cured meats, fatty tissue, water and seasonings, usually smoked and slightly cooked. In Europe, these sausages are known as “scalded” because they are only scalded (pasteurized) and not fully cooked. An important subgroup of larger diameter emulsion-type sausages includes products containing, in addition to previously cured meats, diced or cut into distinctive small pieces.**

- e. Cooked sausages are ready-to-serve products, basically**

made from previously cooked fresh or exceptionally cured raw materials, subjected to final cooking after stuffing, with or without additional smoking. A subgroup of these sausages consists of cooked or baked specialities that are not stuffed into casings but moulded and, therefore, not always considered as sausages.



LAYOUT AND EQUIPMENT FOR A SMALL-SCALE SAUSAGE PRODUCTION PLANT

The problem of developing a good sausage plant layout is relatively complex, however small the plant may be. First of all, it would be inadvisable, and even impossible, to adapt a uniform approach in all countries or regions because of the geophysical, economical and social differences and variations in livestock, the

meat trade, customs and food habits etc. It is always indispensable to make a careful survey of the existing livestock and meat supply conditions before any sausage plant construction or remodelling is proposed. The attitude and outlook of livestock and the meat trade, especially in the less developed regions, must be seriously taken into account. A hindrance to progress may be the bad habits and unhygienic meat handling practices in the local slaughterhouse which intends providing the meats for the sausage plant. The food habits and flavour preferences of the local meat consuming public should also be investigated.

In this chapter technical details are given as well as a description of the underlying principles for sausage plants which may assist those planning new plants or remodelling old ones in consultation with architects to select the most suitable solution for local conditions. Simplicity of design and costs are of particular importance for small sausage plants. These

suggestions have been outlined merely as a guide and they may require modification to suit particular conditions. Because of variations in requirements, a standard blueprint cannot be produced. Only occasionally the standard type sausage plant would be directly applicable to a particular situation. In the majority of cases the design must be considerably modified to meet the local peculiarities of the site selected for the plant, its environment, local handling and transport practices and human and material resources. The local health and veterinary authorities, where they exist, must be consulted before a final decision is taken.

GENERAL REQUIREMENTS FOR ESTABLISHING A SAUSAGE PLANT

Whenever the construction of a new sausage plant or the remodelling of an old one is envisaged, a plan to overcome possible defects is recommended. It is of paramount importance

to draw up a plan giving the greatest efficiency to the entire sausage plant. It is essential to follow a system in planning and designing even if the plant will initially have a small throughput. The remodelling of an old and obsolete plant often requires more compromises than does the design of a new layout.

Commercial considerations.

Economic and marketing considerations are vitally important in determining the most suitable location for a sausage manufacturing plant. The first and the most important consideration is the meat supply, followed by the distribution of sausage products to consumers. The discrepancies between the retail price paid to farmers for live animals and the price for locally sold sausages, which should be determined on the basis of commercial research, are essential factors for choosing a specific geographical area to locate a sausage plant. Rather than build a sausage plant large enough to deal with the periodic

sausage marketing peaks, it is considered advisable to base the size on average daily requirements and to extend hours of processing during peak periods.

Location.

The site of a sausage plant within a distinct area should be selected on the basis of certain factors. Where legislative measures do not exist, there are certain considerations which must be observed. The sausage plant should be located in an area free from objectionable odours, smoke, dust etc. and should be completely separated from any other plant or building. No communication by doors or windows is permissible. Attention should be given to an adequate potable water supply, arrangement for drainage and adequate electric power sources. In planning a sausage plant, consideration must be given to a location or an arrangement of buildings that will permit future expansion.

The traditional location of a sausage plant close to the slaughterhouse is still advantageous since the problems of professional workers and fresh meat and by-product supply are markedly simplified. However, if the sausage plant is well managed, it will do its share of business regardless of whether it is located near to or far from a slaughterhouse. Although it is not customary to have a small sausage factory as an integral part of a small slaughterhouse, occasionally such a situation does occur, either in a private or cooperative form.

Building materials, floors and walls.

In general, the space of a sausage plant must be compact and designed for economical throughput in relation to the capital and operating costs. The whole structure must suit local climatic conditions. Brick, stone, reinforced concrete, and prefabricated steel structures are the most widely used building materials. Although in the tropics it may be cheap and often immune to

parasites, wood is not a satisfactory material for use in a sausage plant.

A non-slip, hard, smooth and impervious floor, that will not absorb moisture and can be readily cleaned, is indispensable. It should be of the best lasting quality. Sharp corners, joining the walls and floor should be avoided. The surfaces of interior walls must be impervious and smooth and made of non-absorbent materials. Walls should be covered and coated with lead-free paint or tiled at least to a height of 1.8 m.

Ceiling surfaces of rooms, where wet operations are conducted, should be smooth and flat and of sufficient height. Natural ventilation is always preferred but very often artificial ventilation is the only solution.

The slop (usually of 1.8–2.0 percent) of floors to drainage inlets must enable rapid disposal of effluent. All effluent drainage lines

must have a sufficient inside diameter of at least 10 cm with the fat traps incorporated in the drainage system. Drainage lines from toilets and urinals should be constructed as a separate system.

The method of sewage disposal should be under the local health authorities' control.

Sanitation.

A well-designed sausage plant cannot be attained through buildings alone. Sanitation is also essential in a well-run sausage producing plant. The hygienic maintenance of equipment and the plant as a whole is a cardinal factor for production efficiency and keeping quality of finished products. Tile walls, hard-surfaced brick or concrete floors, carefully sloped to drains, stainless steel table tops, galvanized metal trucks, barrels and pans are an integral part of a good sanitation programme. Briefly, strict

sanitary methods and conditions must be employed through the entire process.

Provisions should be made for elimination or removal of any vapour which would cause condensatipon on walls and ceilings. A sausage producing plant must be provided with suitable facilities for collection and disposal of bones, ligaments and other offals, and for such wastes as paper etc. Waste containers for bones, inedible fats etc. are needed, especially in the processing area. Lavatories and other washing and shower facilities should be provided for workers of both sexes, supplied with hot and cold water and maintained in a clean condition. Consideration should be given to the incorporation of a small laundry in the sausage plant and also to the provision of changing rooms and eating rooms for employees.

Cabinets must be provided for efficient cleaning and sterilization of trucks and other movable equipment. Equipment is placed in

the cabinets and then sprayed with cleansing solutions, and finally rinsed with clean hot water. Stationary equipment, such as cutters etc., should be carefully cleaned individually, and after that, disinfected and dried. Every possible precaution should be taken to keep the plant free of flies, rats and mice. Screens for outer openings that do not admit entry of files are often useful. Adequate arrangements should exist for effluent disposal.

The governing principle in daily routine cleaning in any sausage plant is the scrupulous cleaning of all contaminated places and surfaces. Brushing and flushing with water under pressure should be the most used method of cleaning. The cutting and trimming section requires exceptionally careful attention.

Steam or hot water is required to remove grease adhering to the surfaces of tables and machines. Detergents contribute considerably in cleaning because they emulsify fat and dissolve proteins. It is of primary importance that disinfection of the

sausage plant is done in connection with general and thorough cleaning. The regular repair of walls, floors and equipment is also an important part of plant sanitation.

Fly control is a basic sanitary step for any sausage manufacturing plant located in a warm climatic region. Although the main objective of fly control is the elimination of conditions encouraging fly development, fly proofing of the sausage plant is strongly recommended. Ants, mosquitoes and other insects, as well as birds, may also be a problem in the tropics against which the sausage plant should adequately protected.

SAUSAGE PLANT LAYOUT

While sausage plant layouts vary widely according to the diversity and volume of products, certain well-defined principles are always respected in present-day plants. Anywhere where space permits, product movement should follow a straight line

pattern, from the receipt of raw material and its storage through trimming, mincing, emulsifying, filling, smoking and cooking operations to the packaging, storage and distribution of the finished product. The main technological and hygienic principles in developing sausage plant layout are the maximum speed in handling raw materials and products and the shortest time intervals between operations resulting in the shortest possible distances consistent with the size and type of the plant.

There are some common requirements determining the layout of a sausage plant. Doubtlessly, the basic requirement is that the raw materials should enter at one end of the building and the sausage products, either chilled or unchilled, leave at the opposite end. The arrangement should be that the meat and products move in one direction without any risk of contamination. The operators are placed along the tables and machines and they move the raw materials and sausages in the necessary direction.

Normally, a sausage plant begins with a receiving and chilling section. When the meats reach the plant by truck, provision has to be made for an offloading ramp. There should be a direct and unobstructed entrance from the receiving area to the chillroom and main processing room. The operation of receipt, weighing and storage of meats should be carried out in a refrigerated room adjacent to the main workroom. Where output permits, nonmeat raw materials (casings, spices, packaging materials etc.) should be dealt with separately in order to ensure a good hygienic standard.

Effort should be made to provide refrigeration in the cutting and trimming room. The deboning and trimming operations should be performed on special tables in a clean and controlled atmosphere. The deboning of hot carcasses should have priority.

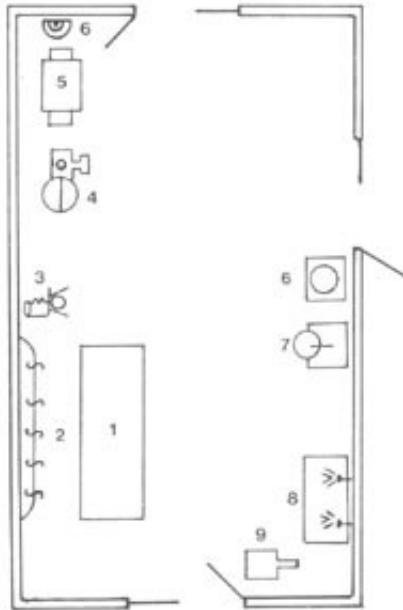
All grinding, chopping, stuffing, linking and other processing operations have to be organized in a separate room. The type

and extent of equipment required for comminuting meat and stuffing sausages depend upon the variety and volume of the operations. For operations of any magnitude, equipment such as an ice crusher or ice generator, knife grinder, frozen meat slicer etc. is advisable.

The meat, after being trimmed, graded, chopped and mixed with nonmeat ingredients, is conveyed from the cutter to the stuffer for filling into casings and then the sausages, hung on smoke rods, are carried from the meat chopping and mixing area to the smoking and cooking facilities. Any sausage manufacturing line terminates in the smokehouse and cooker, where the necessary trucks, cages and other accessories are available. The size of the smokehouse and boiler will depend upon the factory throughput. Adequate provisions should be made even in the smallest plant for weighing, grading, storing and distribution of final products.







**Fig. 2 MEAT PROCESSING ROOM, Institute of Food Technology,
Dakar, Senegal**

Cutting and trimming area:
1 - working table, 2 - overhead rail:

Chopping and mixing area:

**3 - mixer, 4 - grinder and cutter,
5 - vacuum mixer, 6 - steam sterilizer,
7 - colloid mill, 8 - washing vat.**

In such a way, a sausage plant is composed of the following areas or section: (a) receiving and chilling, (b) cutting and trimming, (c) nonmeat ingredients, (d) meat chopping and mixing, (e) smoking and cooking and (f) wrapping and dispatch sections. Layouts of these sections can be combined in varying ways depending on the size and shape of space available, amount and structure of production, the methods selected etc. A proper integration of section layouts is required if maximum efficiency, smooth flow of operations, reduced labour and managerial control are to be achieved.

A good layout always shows a certain degree of adaptability to products other than those shown in the planned programme. The

environment in a sausage plant varies from normal room temperature and normal relative humidity, through hot and highly humid air around the smokehouse and cookers, to cold saturated air in chillers. The sausage manufacturers who intend to make a new or remodel an existing sausage plant should contact the Government Meat Inspection Service and furnish drawings of the plant layout and other information required.

Receiving and chilling section.

The receiving area is the place where all raw materials which arrive are checked and their weight determined by means of a scale. The area around the entrance door must be suitably paved and drained. The receiving section, even in the smallest sausage plant, should be so designed that the meat moves from the receiving door into the processing section with the least amount of time and effort and without any possible interference of operations and contact of the meat with other raw materials.

The selection of type and size of chiller depends largely upon the capacity and character of processing conducted. The temperature of the chiller should be 0° to 4°C. Access to the chiller and its connection with the cutting and trimming area must be easy. The chiller must have separate areas with suitable facilities for holding by-products and meat curing; a freezing department is advantageous.

Cutting and trimming section.

This section, adjacent to the chopping and stuffing area, includes the space occupied by cutting and trimming tables; there should be sufficient room for free movement and safe use of knives, cleavers and other tools. A room temperature of 13°C is considered good practice. The humidity should be low enough to give a dew point close to that of the surface temperature of the product.

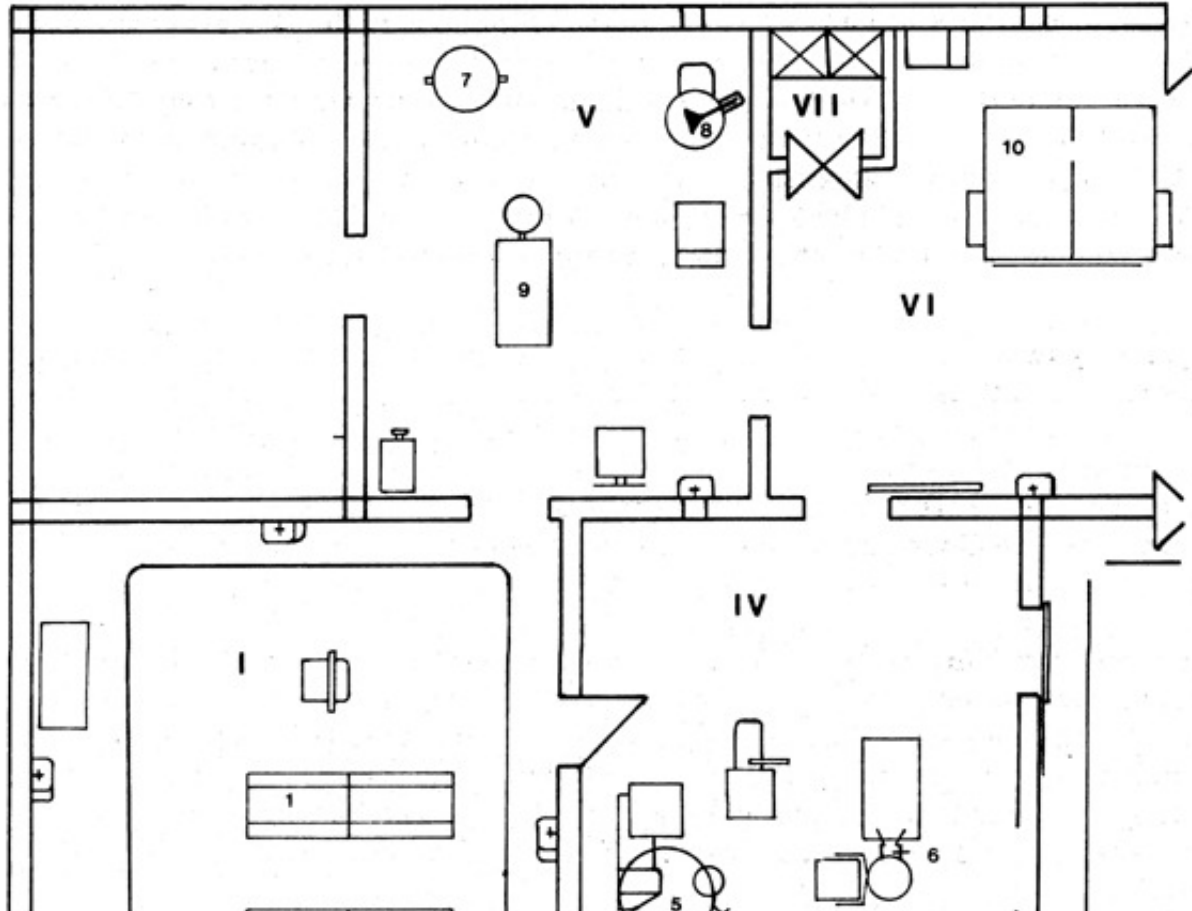
Nonmeat ingredients section.

This section needs a separate, dry and cool area, protected from insects and humidity and provided with tables, scales and other facilities for storage, control and preparation of spices, casings, containers etc.

Meat chopping, mixing and stuffing section.

This section includes the space in which the meat is processed, mixed with other ingredients and stuffed into casings. This section is occupied by basic processing equipment such as a grinder, cutter, mixer, stuffer and working tables. It is extremely important that all equipment is designed for easy cleaning.

The layout of the section deserves particular attention. Each item of equipment should be located to permit easy access to the operator.



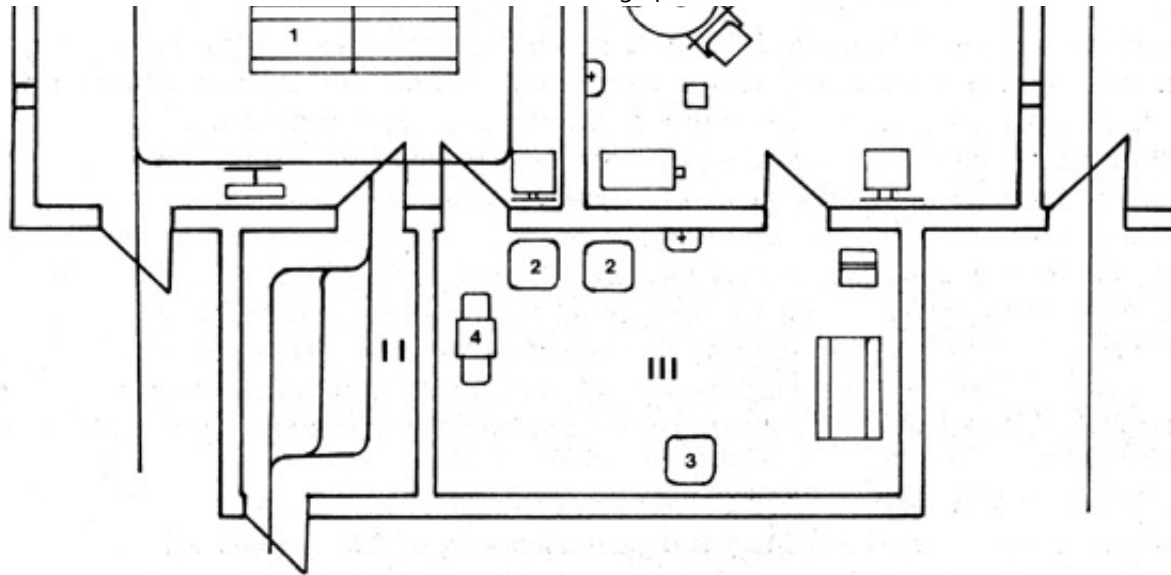


Fig. 3
SMALL-SCALE SAUSAGE MANUFACTURING PLANT IN BECEJ,
YUGOSLAVIA
Courtesy of Prof.Dr R. Rede, Food Technology Institute, Novi
Sad, Yugoslavia)

**I - Cutting and trimming section, II - Chilling section, III - Meat curing section,
IV - Chopping and stuffing section, V - Cooking section and chopping and stuffing cooked sausages,
VI - Smoking section, VII - Equipment sanitation area.**

**1 - Trimming table, 2 - Curing vat, 3 - Massager, 4 - Pickle injector, 5 - Cutter, 6 - Stuffer,
7 - Cooker, 8 - Cutter, 9 - Working table, 10- Smokehouse.**

Smoking and cooking section.

The principles, applicable to the layout of this section, are:

- **the smokehouse should be built so that its fireplace opens externally; good air and smoke circulation in the smokehouse is essential and a thermometer for checking the temperature is highly desirable,**

- **the smoking and cooking section should be well isolated from other areas; adequate ventilation is an important prerequisite.**

Wrapping, storage and dispatch section.

The type and size of this section are determined not only by the number and structure of finished products but mainly by the method of marketing. This section may be located in an outside main building. In smaller plants some wrapping operations may be done in another section at the end of the work-day. Special attention should be devoted to the arrangement of an adequate storage area.

BASIC SAUSAGE PLANT EQUIPMENT

Selection of the proper type of sausage producing equipment involves the consideration of a number of factors, such as type

and volume of production programme, labour, speed of production desired, ability to vary quickly the type of sausage, price of raw materials, cost of maintenance etc. A proper sequence of operations and a wise choice of equipment can considerably aid the economical and successful flow of operations and avoid bottlenecks impeding the process. Great care should be given to the choice and placing of machines and other equipment in such positions that not only will one be capable of performing the most effective work but also of moving raw materials and products from one operation to another with minimum contamination. Adequate importance must be given to each separate item of equipment bearing in mind that too large a machine is an unnecessary expense but, a machine which is too small, is a permanent handicap.

Special points to consider in the selection of any equipment are:

- **appropriate material to minimize corrosion,**

- **robust construction in order to minimize maintenance,**
- **satisfactory design to enable handling and processing of meat and other raw materials and to facilitate thorough cleaning,**
- **capacity to meet requirements.**

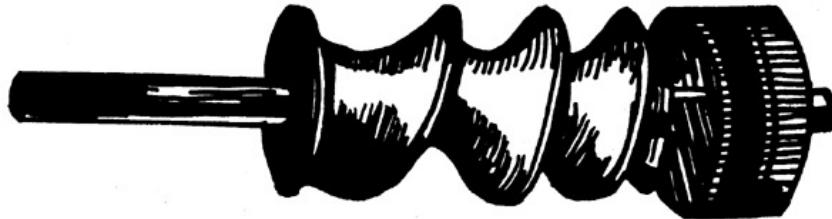
All equipment should be provided with the necessary safeguards so that its operation will not be hazardous.

Grinder (mincer).

The meat grinder is a sausage making tool that forces meat scraps under high pressure along a horizontally mounted cylinder with sharp-edged ribs through a series of holes in a perforated plate. As the compressed meat extrudes through the holes in the plate, a revolving four-bladed knife cuts it. The perforated plate has round holes ranging from 1 to 13 mm. The

degree of comminution is most of all determined by the choice of the hole diameter in the perforated plates.

Table grinders usually have 70 to 98 mm cylinders with the finest plate being 1 mm. The cylinder diameter of a large industrial grinder can reach up to 300 mm. Grinders are usually employed as the first step in the comminution of meat.



2

Fig. 4 WORM OF FEED SCREW OF A GRINDER



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Fig. 5 ELECTRICAL GRINDER (Electrowolf 114 mm)
The machine is equipped with a worm or screw feed and hand operated (*Photo courtesy of Kraemer und Grebe, GmbH & Co KG, D-3560 Biedenkopf-Wallau, W.Germany*)

The grinder should never run empty as this ruins the knives and plate. Frozen meat or meat rich in connective tissue is grinded first through a coarse plate and then through a fine plate. All parts of the grinder coming into contact with the meats are made from corrosion-free materials.

Mixer.

Mixers are primarily used in obtaining a well blended mix of

ground meat, fat and spices for coarse-ground sausages. Mixing under a partial vacuum has some advantages, especially in the preparation of dried sausages. The machine generally consists of a rectangular round-bottom vessel through which run two parallel shafts equipped with wing-shaped paddles agitating the meat mass back and forth to give a uniform distribution of fat and lean particles, spices and other ingredients. Discharge is usually by tilting the mixer 90 degrees. Overloading the mixer prevents good mixing.



Fig. 6 GRINDER (Winkelwolf 130 mm) EQUIPPED WITH A DEVICE FOR SEPARATING THE CARTILAGE, TENDONS AND BONE PARTICLES FROM MUSCLE TISSUE
(Photo courtesy of Kraemer und Grebe, GmbH & Co KG, D-3560 Biedenkopf-Wallau, W.Germany)

Tumbler (massager).

Various machine tumbling or massaging systems are available. Different types of these machines differ greatly in their efficiency. A non-expensive tumbler which comes up to the requirements of each small-scale sausage manufacturer has been developed from the concrete-mixer. In the most expensive tumblers the meat is tumbled in regular time intervals.

Cutter (chopper).

Cutters are designed to comminute meat materials very finely by revolving them in a bowl with rapidly rotating knives.

The cutter is today the most frequently used meat-chopping machine. There are many cutter types and sizes and it is not always easy to select a cutter having the right capacity and highest efficiency for a given product. Cutters, commonly found

in meat processing plants, are essentially composed of a horizontally revolving metal bowl equipped with a set of curved very sharp knives, mounted on a horizontal axle rotating at high speed. The knives are guarded with a cover. The arrangement, number, shape and speed of knives are the main factors in a cutter's performance.

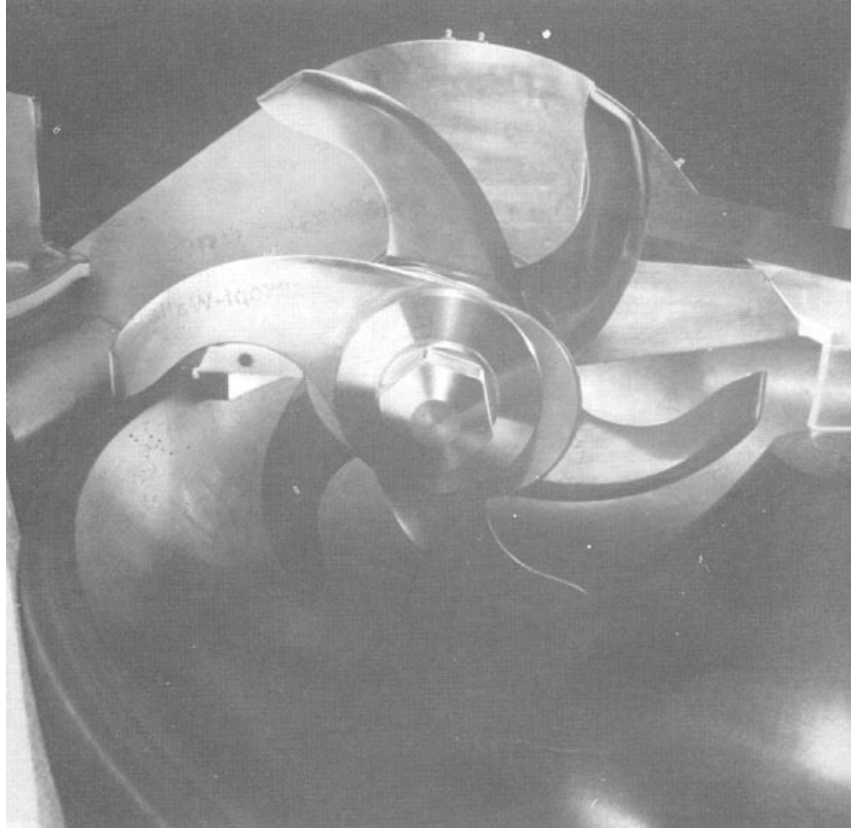


Fig. 7 HIGH-SPEED KNIVES IN A STANDARD CUTTER

(Photo courtesy of Kraemer und Grebe, GmbH & Co KG, D-3560 Biedenkopf-Wallau, W. Germany)

Modern cutters usually have dual-speed knives and a variable bowl speed; they are often equipped with a special device for emptying the bowl as well as a thermometer over the bowl to help in controlling meat temperature during chopping. They can operate under vacuum which contributes to a better colour and improves the water binding capacity of the meat.

Quite small cutters usually have a 15 to 30 litre bowl with two speeds of bowl rotation and knives rotating at 1000 to 2000 per minute. Such cutters can be operated by 12-15 HP motors. Cutters for small-scale sausage manufacturers have 25 to 50 litre bowls with a variable bowl speed and knives rotating at 1500 to 3000 per minute. Some machine manufacturers supply cutters with knives rotating at 4000 to 5000 rpm. Cutter power requirements are high: a cutter with a bowl capacity of 200 to 250

kg needs a 75 HP main motor and a 3 HP auxiliary one.

The knives should be maintained in a thoroughly sharp condition; periodically they need a superficial finish with a fine stone. The cutter knives should be adjusted to the bowl at a distance of 0.7 mm.



Fig. 8 STAINLESS STEEL CUTTER EQUIPPED WITH A PROTECTION COVER.

Bowl capacities of 45, 65, 90 and 120 litres (*Photo courtesy of Kraemer und Grebe, GmbH & Co KG, D-3560 Biedenkopf-Wallau, W. Germany*)

A combined machine, consisting of bowl cutter and grinder, often fits the work requirements in a small-scale sausage plant. Most of the larger and faster cutters are now equipped with devices which enable easy loading and emptying of the bowl.

Emulsifying mill.

In recent years, new equipment such as an emulsifying mill has been designed for preparing meat emulsion. The emulsifying mill has proved itself in the meat processing industry all over the world. It usually includes a perforated plate on which a two-edged blade rotates, i.e. cutting knife or knife rotor. Immediately

below the plate is a centrifugal pump that forces material through the perforated plate. At present emulsifying mills are constructed with many cutting combinations, in either vertical or horizontal units. One design of these machines has a cutting action of two corrugated face plates: the outside rotating at 2000 to 2500 rpm (coarse chopping) and the inside, which is stationary, regulating the particle size of the meat (fine chopping).



Fig. 9 THE CUTTER EQUIPPED WITH DEVICE FOR EMPTYING IT

WITHOUT THE USE OF THE HAND

(Photo courtesy of Kraemer und Grebe, GmbH & Co KG, D-3560 Biedenkopf-Wallau, W. Germany)

Compared to the cutter, the emulsifying mill operates at a much higher speed, producing a finer emulsion. Normally, the emulsion is ready for stuffing by one passage through the machine.

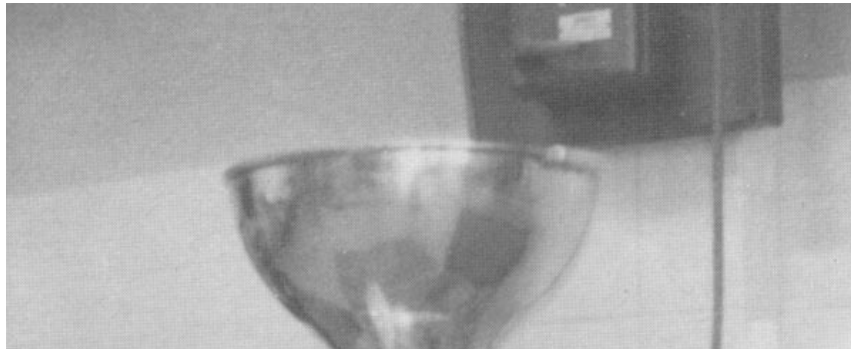
Frozen meat cutting machines.

The most common machines for cutting frozen meats are guillotines and rotating cutting machines.

Guillotines are relatively simple, not too expensive space-saving cutting devices that can be adjusted to give different thicknesses of meat cuts. A distinction should be made between guillotines with a horizontal working table (cutting blades move in an up-and-down direction) and those with a vertical cutting knife

(cutting blades move in a sideways direction). Fully automatic guillotines have been developed for large-scale sausage plants.

Machines operating on the blade-rotating principle are cutters, flakers and dicing machines. Cutters can produce a desired uniform size reduction of the frozen raw material (meat or fat) without smearing it. Flakers are equipped with beak-shaped cutting blades to chip or peel off the frozen meat block into flakes. The dicing machines are used in the manufacture of cooked sausages for giving a dice-or disc-shaped form to different raw materials.



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Fig. 10 EMULSIFIER IS A MACHINE COMBINING THE PRINCIPLES OF GRINDING AND CHOPPING

Stuffer.

There are two well-known and proved systems used for stuffing of the emulsion in casings or in other containers. First, the common or piston filling machine, or simply, a stuffer which is a compressed air-driven or hydraulic or manually operated machine. The vertical piston stuffers are popular among small-scale sausage manufacturers. They are recommended for coarse-ground sausages but they are also useful for fine emulsion stuffing. The pump stuffers, working often on a continuous basis, are preferred by large-scale sausage manufacturers.

The piston stuffer is a cylinder, equipped with an easily movable cover and a piston moving upward pushing the mix into the

casing through a stuffing tube or horn of suitable size. The larger the diameter of the stuffing horn, the lesser will be the smearing of the mix. Attachments (twist-off or dividing devices) are provided to permit stuffing of desired amounts of sausage mix in the production of small, uniform-weight sausages.

The second system of stuffing the meat emulsion or mixture into casings is the continuously-working stuffing machine. This type of stuffer has a great advantage for large-scale producers: its filling funnel may be refilled without stopping the machine.

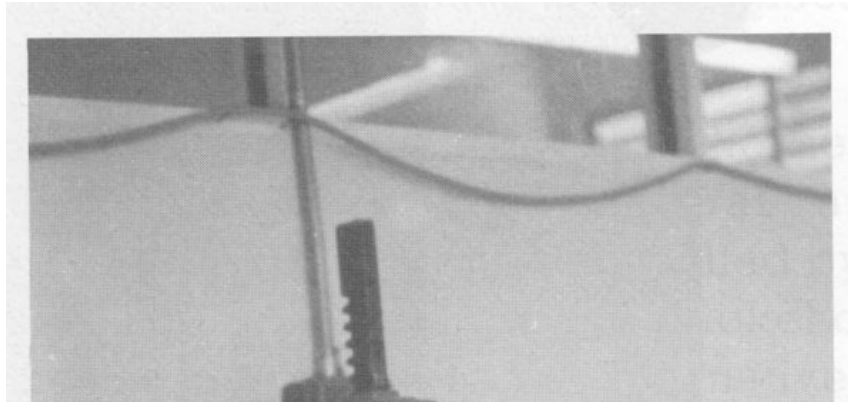
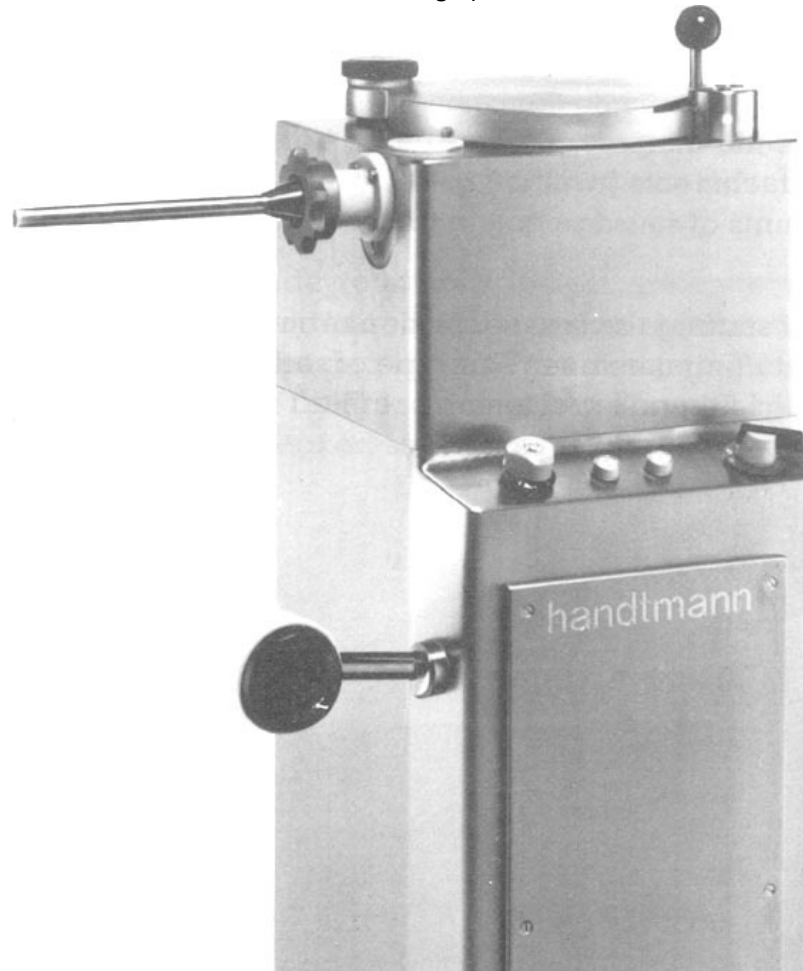




Fig. 11 HAND STUFFER



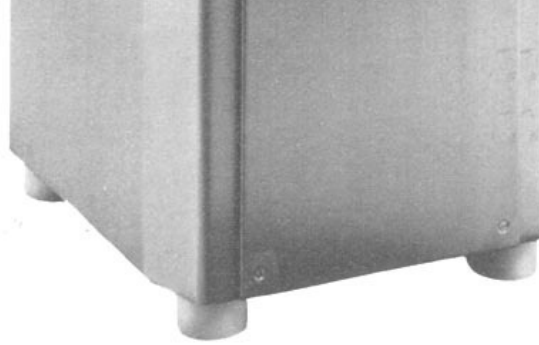


Fig. 12 PISTON FILLER F 30 S-TOP FOR ALL TYPES OF SAUSAGES. WHETHER COARSE-CUT OR FINE.

The machine housing, cylinder and outlet are constructed in stainless steel; filling pressure is provided from a trouble-free hydraulic pump; barrel capacity 30 litres.

(Photo courtesy of Albert Handtmann, GmbH & Co KG, D-7950 Biberach/Riss 1, W. Germany)

Linker.

Linking of filled casings by hand is done on a stuffing table; this manual operation is particularly practised for large diameter sausages. Semiautomatic clipping machines are also available to close the end of large diameter sausages.

Linking machines tie the stuffed small-and medium-diameter casings (with thread or twist) into units of desired uniform length; this method greatly reduces the labour cost when the size of operation justifies its use. Machines that stuff and link are today the accepted practice in medium- and large-scale production. After the sausages have been linked, they are placed on rods which are hung either on racks or cages suspended from overhead rails or upon trucks.

Smokehouse.

There are two basic types of smokehouse: the simple or natural-air-circulating smokehouse and the modern or air-conditioned

smokehouse. The design of a smokehouse has a great influence an obtaining uniform results.

The natural draught smokehouses are made of brick, hollow tile and stone or they are of metal construction; also they can be improvised with other materials. Walls are, if possible, insulated and coated with a smooth surface of enamel. The fireplace can be located either outside or directly inside the smokehouse at one end. In any case, the circulation should be so directed that the smoke is uniformly distributed throughout the chamber. A false ceiling is built 65–90 cm below the roof and is sloped to allows several openings for the escape of smoke. Such a construction eliminates condensation. The roof of the building is insulated and is provided with one ventilator for venting the smoke into the atmosphere. The ventilator is equipped with a damper for controlling the amount of draught. This type of smokehouse is usually located in a separate building.

Modern or air-conditioned (forced ventilation) smokehouses are equipped not only to smoke but also to cook and chill the sausages. Their walls are usually fully insulated. Air circulation is created by fans and humidity is controlled by steam injectors or by varying the amount of outside air introduced into the smokehouse. Air temperature is maintained by a series of connected gas-heated or alternatively heated pipes. With this type of smokehouse, especially designed sawdust smoke generators are extensively used. The generated smoke is drawn by a fan into the smokehouse. The use of generators facilitates control of the density of smoke and allows the elimination by washing of soot and other undesired particles formed during the combustion process.

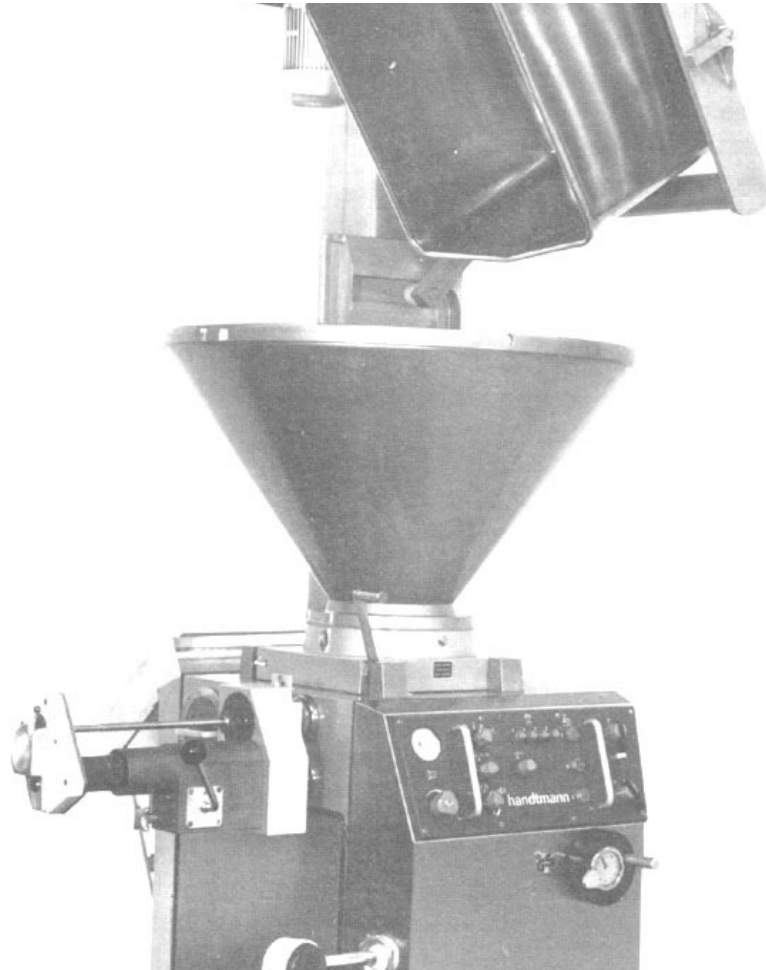
Special attention must be given to the control of temperature and humidity in the smokehouse. In this respect wet-bulb (black) and dry-bulb (blue) thermometers are often used but other instruments are also in common practice. Records of these

thermometers should be carefully checked each day. Keeping the smokehouse clean does much toward preventing fire and contributes to the quality and shelf life of sausages.

Cooker.

Cooking of sausages, particularly the large kind can be done by submerging them in hot water in steel tanks or in a steam-jacketed round-bottomed kettle. To avoid heat loss and shrivelling, sausages that are not cooked in the smokehouse should be moved immediately after smoking to the cooker. Another method, used for small-diameter sausages, is cooking in special cooking cabinets; after cooking, sprays of cold water chill them to an internal temperature slightly above room temperature.





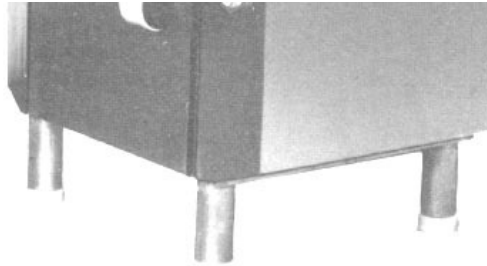


Fig.13 VACUUM FILLER VF 12-200.

Machine for fast portioning and linking of sausages, jars, cans and containers in exact portions; 200-, 150- and 100-litres hopper; lifting device.

(Photo courtesy of Albert Handtmann, GmbH & Co KG, D-7950 Biberach/Riss 1, W. Germany)

After cooking, the cage on which the sausages are hung is removed. The remaining heat is normally sufficient to dry the sausages prior to their placement in the chiller at 2-8°C.

Tanks for cooking raw materials or sausages in water are usually square and of a convenient size and depth for loading and unloading. The choice of the type of cooking tank should be in line with the given capacity, raw material available and type of final product.

Tools.

The sausage plant must be provided with a collection of different hand tools, such as various types of knives, cleavers, sharpening steel, knife racks, metal or wooden smoke rods, thermometers to register temperature of meat during chilling or cooking, plastic chopping blocks and cutting tables, motor-driven chopping block cleaner, semiautomatic price indicating scale, clip machine for large calibre sausages etc.

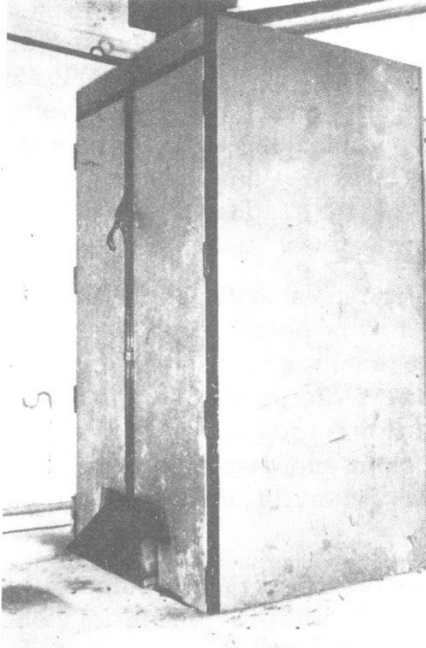


Fig.14 A SIMPLE SMOKEHOUSE



Fig.15 SMOKING TROLLEY FOR THE SMOKEHOUSE





SAUSAGE RAW MATERIALS

The selection of ingredients is basic for the production of sausages of uniform standard quality. Although beef, veal and pork are the main meat sausage materials, mutton, poultry and other kinds of meat, together with edible by-products, are also of importance. Apart from meat raw materials, a number of nonmeat ingredients, such as curing salts, sugar, spices and casings, are increasingly used in sausage production. The regulations in many countries have an important bearing on the use of different ingredients in sausage formulations; however, in a number of developing countries no regulations exist or they are not applied. In developed countries particularly, there is governmental pressure to reduce the amounts of salt, nitrite, nitrate and other additives or ingredients in different kinds and types of sausages.

MUSCLE MEATS

Skeletal muscle meats from slaughtered animals are the principal ingredients used in sausage production. However, the different skeletal muscles vary not only in their contents of fat, water and proteins, but also in their water binding and emulsifying properties, colour, etc. This is the reason why all skeletal muscle meats, such as different cuts of carcasses, including cheek and head meats and trimmings, as well as other muscle meats, such as hearts, weasand meat (muscular part of oesophagus) and gilet meat (fleshy portion of diaphragm), are regularly subdivided according to their fat-to-lean ratios and their water binding properties.

The control of moisture, fat and protein is difficult due to the fact that is not possible to obtain a high degree of uniformity in the lean and fatty meat ingredients in various sausage formulations. For instance, considerable variations from one lot of beef or pork

trim to another are possible. There is considerable variation between the animals themselves; the trimming operation also introduces variations. The sausage producer should control these variations in the sausage mix in order to obtain a more uniform finished product which, obviously, will have more appeal from the customer's viewpoint.

Meat trimmings in particular vary in kind and quality. Thus, in order to achieve an accurately formulated product, the trimmings should be classified according to fat, moisture and protein content, as well as the species of animal from which they originate. Under this classification, fat pork trimmings consist of more than 40 percent of fat.

In a similar manner lean beef (comparatively free from fat, as chuck and neck trimmings) is distinguished from larger portions of fat, such as flank or rib trimmings. Lean beef trimmings and generally lean beef cuts are preferred for use in fermented

sausage products where a large percentage of beef is essential. Meat trimmings are relatively perishable and great care must be exercised to keep trimmings in a fresh condition.

Meats of high and low water binding properties.

Meat showing high water binding properties are recommended for emulsion-type sausage manufacture; they are bull, cow and calf meats, beef trimmings, beef chucks, lean pork trimmings and skinned poultry meat. Many high-value beef cuts, not suitable for direct sale because of bruising or other defects, may be utilized in sausages after the damaged parts have been trimmed away. Such meats are normally characterized by a good water binding capacity while veal also gives a light coloured sausage. Mutton has superior binding properties, but due to its strong flavour, its usage is ordinarily limited to about 15–20 percent of the total meat. Despite this fact all mutton sausages have a high reputation in a number of countries.

Buffalo meat is seldom used for sausage production. Usually buffaloes are slaughtered at an advanced age when they have reached the end of their useful working life as draught or milk-producing animals. The age factor probably accounts for the general opinion that buffalo meat is unacceptably tough. Buffalo meat gives a dark coloured sausage but has excellent binding qualities.

Beef flank and beef and pork cheek head and shank meats possess intermediate binding properties. Beef and pork cheek and head meats are removed from the head of the animal at the same time and thoroughly washed to remove adhering blood. They are quickly chilled or immediately used in various sausage formulations. Shoulders and other pork cuts are also deboned and the meat used in sausages.

Fat pork trimmings, hearts, beef briskets, porkjowls, weasand meats and giblets are meats of inferior binding capacity. When

such materials are used in a sausage formula, the sausage manufacturer must proceed more carefully as these tissues contain a relatively large amount of free water with a highly varied water-to-protein ratio.

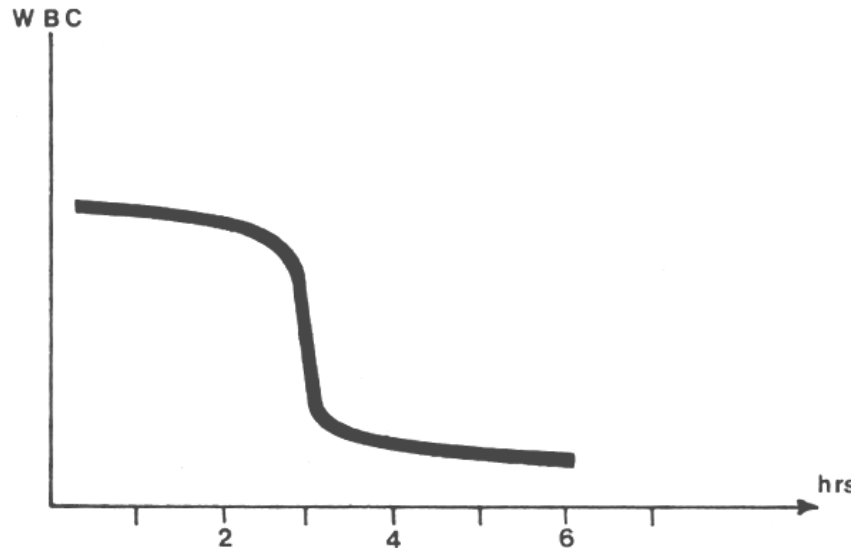


Fig.16 DECREASE IN WATER BINDING CAPACITY (WBC) IN

Small-scale sausage production
POSTMORTEM MEAT

Superior sausage-making properties of hot boned beef.

Meat, removed from the carcasses of bulls immediately after slaughter (within 1 to 2 hours), has long been appreciated in traditional European sausage production. Experience has shown that using such prerigor boned bull beef in meat emulsion can be a tremendous advantage resulting in a product of superior water binding and emulsifying properties with improved flavour, texture and stability of the finished product (Fig. 16). The reason for better binding and emulsifying characteristics of prerigor meat lies in the extraction of salt-soluble proteins (actin and myosin) before they combine to form nonextractable actomyosin causing the onset of *rigor mortis*. The addition of 2 percent of salt to prerigor beef results in the absence of *rigor mortis*, an increase of extractable proteins and enhanced water binding and emulsifying properties compared with conventionally chilled meat

which has gone into rigor without the addition of salt. The maintenance of superior functional properties of prerigor meat requires either its salting or rapid freezing and its use without thawing or freeze-drying after salting.

Refrigeration and technological development has moved the meat industry away from prerigor meat processing and separated the slaughterer from the sausage manufacturer. Thus, the meat industry is presently accustomed to handling chilled postrigor meats.

Although there are reasons for using prerigor meats in many meat products, its main field of utilization is doubtlessly in emulsion-type sausage manufacture where the greater water binding and emulsifying capacity can be better utilized. Prerigor meat processing would be particularly advantageous for those small-scale manufacturers who do their own slaughtering. On the other hand, major changes in modern meat industry practice in

developed countries must be made if prerigor meat is to be used again in meat processing.

Hot meat intended for emulsion-type sausage manufacture should be derived from carcasses immediately after slaughter. The forequarters are normally first deboned, trimmed free of fat and sinews, chopped and mixed with salt. Then the same is done with the hindquarters. The reason for giving processing priority to forequarters is that the onset of *rigor mortis* occurs earlier in forequarters (within 2 to 4 hours) than in hindquarters (within 3 to 5 hours). The use of bull meat, which is normally very lean, is an advantage since its trimming process is relatively short compared, for instance, with cow meat.

FATTY TISSUE

All types of fat can be incorporated in sausage mixtures but in general carcass fats are preferred. Internal or body fats can also

be used.

Immediately after its removal from the body, fatty material, particularly internal fats, must be washed in cold water, classified according to fat-lean ratio and thoroughly chilled. Care should be taken to prevent oxidation and eliminate any kind of impurities, odours, etc.

Total fat of an animal body is composed of three main fat deposits: subcutaneous, intermuscular and kidney knob and channel fat.

Subcutaneous fat represents the peripheral layer of fat to the level of the connective tissue covering most surface carcass muscles but excluding *M. cutaneus trunci* which lies in the subcutaneous fat. Subcutaneous fat, particularly pork fat, is widely used in sausage manufacture.

Intermuscular fat includes the fat lying between the muscles, together with thin connective tissue, small blood vessels and small muscles that are physically difficult to separate. In the preparation of meat for raw sausages, accumulations of intermuscular fat should be trimmed as best as possible.

Kidney knob and channel fat encompasses the perinephric and retroperitoneal fat. The restricted quantities of this fat can be incorporated in emulsion-type sausages.

The amount of added fat depends on the type of sausage and on the fat content of meat used in its manufacture. The role of fat varies according to the type of sausage. In emulsion-type sausages the fat is part of a complex system, participating in forming the product's characteristic structure. In raw sausages, fat contributes to the specific taste, aroma and consistency of this type of product.

Some observations concerning the choice and use of beef fat in sausage products.

Beef fat is a valuable raw sausage ingredient which requires special care. It easily becomes sour or rancid if improperly handled or if kept under improper conditions. Beef fat should preferably be used as fresh as possible, without freezing and storing. If, however, beef fat must be stored, the storage temperature should not exceed 5°C.

Old or rancid fat should never be mixed with fresh fat. Old fat will simply contaminate and ruin any other fat mixed with it. The unprocessed meat sausage mass containing such fat very often appears to be entirely fresh but the finished sausage may still be of a low organoleptic value or quite inedible.

The best fats for making all beef sausages are brisket fat and back fat. The white fat of not too young beef animals is preferred

for sausage making. Firm white fat is associated with quality sausages.

VARIETY MEATS

Variety or fancy meats are also used in sausage manufacture. They include tripe, tongues, livers, blood or blood plasma, brains, lungs, udders (nonlactating), spleens, suet and cod and brisket fat, pig stomachs, gelatinous skins, pig backfat and caul fat, ears, snouts, ox lips etc. They are of inferior binding capacity. However, prepared and processed thoroughly as when used in sausages, they are palatable and nutritious.

Tongues, after removal from the head, are washed, chilled and trimmed. After the livers have been removed from the carcass and veterinary inspected, the gall bladder is cut off. Care is exercised not to puncture the bladder because the gall of the bladder would spoil the liver. The livers are washed with a

minimum amount of water. They are kept in a chiller or freezer if not used immediately. Calf and pig livers are particularly used for the manufacture of liver sausages.

Hearts are cut open, washed and chilled or frozen. Kidneys are skinned, trimmed free of fat and chilled or frozen. In obtaining tripe, the rumens are cleaned, carefully washed, hand-scrubbed with brushes and their mucous linings are removed; they are then trimmed of adhering tissues, cooked, trimmed free of fat and used in sausage manufacture or kept in a chiller or freezer for future use. Pork stomachs are cut open, emptied and washed; mucous coating is then removed and the stomachs are cooked, chilled and used in sausages.

STORAGE OF MEAT RAW MATERIALS

Meat fat and other meat raw material used in sausage production are stored at a temperature between 0° and 3°C, if unfrozen.

Similar temperatures are employed for storing edible by-products.

Frozen meat must be stored at minus temperatures corresponding to the degree of meat freezing required ranging from -8° to -20°C.

It is not absolutely necessary to control storage humidity. It usually ranges from 80 to 85 percent. It is highly desirable, however, to keep the walls and ceilings free from condensation because any moisture drip upon the product is a source of contamination.

BINDERS, FILLERS AND EXTENDERS

A number of nonmeat ingredients are included in sausage formulations by many manufacturers, especially in lower or medium-grade sausages and loaves. These ingredients are

commonly known as binders, fillers and extenders. The use of binders, fillers and extenders is not always justified and many people object to sausages containing them. Many countries have restrictions on type, amount and quality of binders, fillers and extenders used in sausages. Products containing more nonmeat ingredients than allowed by meat inspection standards, must be marked as “sausage imitation”. Products where the word “meat” does not appear in the name, or which are labeled as “imitation”, are not restricted in their content of extenders.

Binders are proteinaceous agents enhancing water binding properties and helping in binding together different materials in sausage products; sometimes they also contribute to fat emulsification.

The most important protein products are: sodium caseinate (90 percent protein), soy protein isolate (90 percent protein), vital wheat gluten (80 percent protein), soy protein concentrate (70

percent protein) etc. Many of these proteins are used by meat processors for their functional (binding, emulsifying, extending) attributes rather than for their nutritional fortification. Functional properties of these proteins contribute to structural, emulsifying, binding and gelling qualities in sausages as well as to colour and flavour. Solubility and water absorption influence the functional performance of these proteins in sausage systems. Different factors, such as methods of soy protein production, contents of salt, pH, temperature etc., affect solubility and water absorption.

Addition of blood plasma proteins (obtained, for example, by centrifugation of beef blood mixed with an equal volume of 0.9 percent NaCl solution, containing 0.5 percent sodium citrate) also improves physical and nutritional properties and yields of some sausage products. Whole blood protein powders also show important emulsifying properties but blood powders impart a dark colour to sausages. Plasma and globin proteins, separated from the blood and decolourized, exhibit excellent functional

properties.

Fillers are carbohydrate products able to adsorb extensive quantities of water but they are not good emulsifiers. Common fillers, which are used in sausage manufacture, include cereal flours and starches derived from rice, corn, potato, rusk (a cracker meal obtained by baking an unleavened high protein wheat flour), bread etc. Corn syrup and dried corn syrup contribute to the texture of products. These fillers may be added to sausages to increase their water binding capacity and/or to provide protein which can act as an emulsifier. Potatoes can also be processed to provide starch, flour and proteins which can be used in sausage production.

Flours often give the sausages a somewhat tight structure. Potato flour binds moisture in cooked and emulsion-type sausages, but in fresh sausages it causes a springy and resilient effect after drying. Cooked rice tends to give a fairly firm texture

while corn flour contributes to good slicing characteristics. Pre-soaked rusk contributes to an even moisture distribution in the sausage, and yeastless bread may improve both the texture and flavour of the sausage.

Sausage raw materials characterized by inferior binding properties such as tripe, skin, snouts, pork stomachs, lips etc. are often considered as “filler meats”.

The term “extenders” usually covers nonmeat materials, added in such an amount that they are able to increase the bulk or modify the quality of a sausage or loaf product. Meat extenders are primarily plant proteins, usually from soybeans. These are first prepared as a flour, a concentrate or an isolate (to a protein level of 90 percent or more). Then, they are further processed to produce the end-product which is often textured to resemble meat fibres. Vegetable proteins are used as extenders for ground beef, for example hamburgers. To an amount of 75 percent of

ground beef, 25 percent of a mixture of three parts water and one part vegetable protein, is added. Such a protein extruded meat product has a high water binding capacity.

SALT (SODIUM CHLORIDE)

Salt is the main flavouring agent used in making sausages and it contributes to basic taste characteristics of the final product. The amount of salt added depends on the sausage type and particularly on the fat content but in general it ranges from 1.8 to 2.2 percent of the sausage mix. An acceptable level of salt in dry or semidry sausages is about 3 percent. However, higher and lower salt levels are often used.

Although salt is not generally used in concentrations sufficient to effect preservation it exerts some antimicrobial activity. Some bacteria are already inhibited at 2 percent levels of salt. Other microorganisms tolerate a much higher concentration of salt.

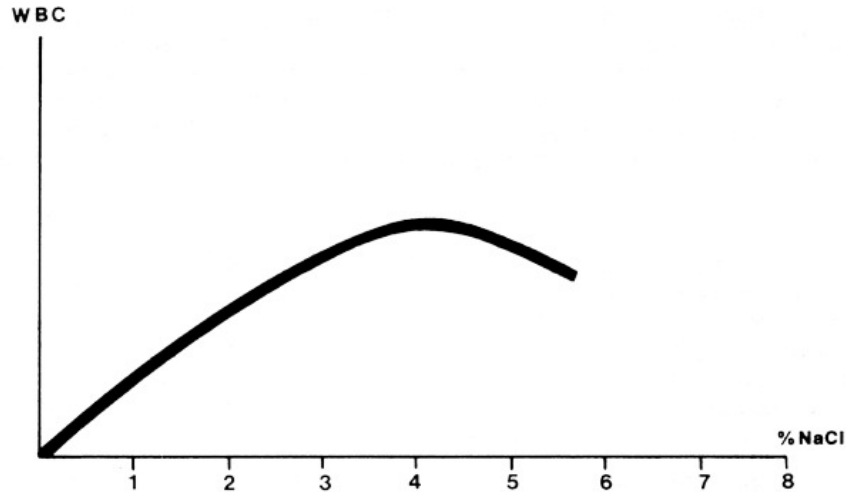


Fig.17 EFFECT OF NaCl LEVEL ON WATER BINDING CAPACITY (WBC) OF MEAT

Salt also performs other functions in sausage. It dissolves in water and aids in the water binding and emulsifying capacity of meat proteins. Use of salt alone gives a dry salty product which has an unattractive colour. Today, salt is generally used in

combination with sugar and nitrite. Salt should be pure and sufficiently finely granulated to dissolve easily in the meat.

NITRITE AND NITRATE

Nitrite and nitrate exercise a powerful influence, imparting the desired colour to the meat. Nitrate serves chiefly as a source of nitrite. Reduction of nitrate to nitrite requires a relatively high population level of nitrate-reducing bacteria which is highly undesirable, especially in warm climates. Since nitrite has a quicker reaction, it is widely used in place of nitrate.

In order to fix the colour of meat, the nitrite must change into nitric oxide (Fig. 18) which actually combines with myoglobin to form a pink-red nitrosylmyoglobin or pigment of cured meat. There are several conditions under which nitrite can be reduced to nitric oxide: (a) at pH below 5.5; this convention is accelerated by the addition of deltagluconolactone which forms gluconic acid

thus lowering the sausage pH; (b) by mitochondrial enzymes under anaerobic conditions; but in rapid curing, it is conceivable that the formation of cooked cured meat colour follows mainly nonenzymatic pathways; (c) by adding reductants (ascorbic acid or its sodium salts) which greatly accelerate nitric oxide formation.

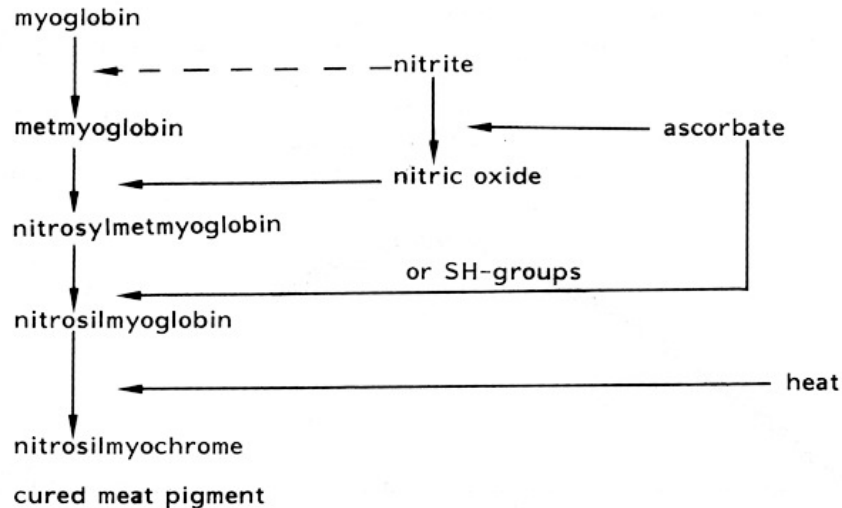


Fig.18 ROLE OF NITRITE, ASCORBATE AND HEAT IN CURED MEAT PIGMENT FORMATION

The initial reaction in the nitrosylmyoglobin formation is likely to be the oxidation of myoglobin to metmyoglobin by the nitrite itself; the metmyoglobin is then converted in nitrosylmetmyoglobin (Fig. 18). The latter is reduced to nitrosylmyoglobin either endogenously or by reductants (added ascorbate or sulfhydryl groups released during heating of meat). Finally, the best denaturation of the globin portion of myoglobin produces the pink coloured nitrosylmyochrome). Approximately 10 to 30 percent of the added nitrite remains intact as residual nitrite, 45 percent is consumed for curing colour and nitrate formation, while the remainder is involved in other reactions. Oxygen and light contribute to fading; the presence of rancid fats, hydrogen peroxide of bacterial origin or excessive amounts of nitrite in fermented sausages cause a greening of pink pigment.

In many countries the use of nitrite has been permitted provided that its residual amount in the finished product does not exceed 180 to 200 parts per million. The most popular commercial and technological form of nitrite used is the so-called “nitrite and salt curing mixture”, containing 0.5 to 0.6 percent of added sodium nitrite and 99.4 to 99.5 percent of sodium chloride. If this salt-nitrite mixture is added to meat at a level of 2 and 3 percent, it will result in 100 and 150 ppm nitrite respectively. These amounts of nitrite and sodium chloride, combined with low pH and water activity of meat and following the heat and/or smoking process, are the main bacteriostatic factors determining shelf life of the final product.

The appearance of the characteristic pink-red colour in sausages is a good sign indicating that the proper sequence of events in conversion of raw materials into a ready-to-eat product has occurred. The absence of the pink colour or development of brown or grey discoloration always indicate that spoilage is

under way or will soon occur.

The use of nitrite in cured meats has been questioned during the past few years. The foremost concern was that nitrite might react with secondary and tertiary amines present in meats with subsequent formation of carcinogenic nitrosamines. This concern has resulted in a trend to eliminate nitrates and reduce the amount of nitrite in cured meats. To date, reduction from 200 ppm residue in final products to 120 ppm ingoing nitrite has occurred in a number of countries. In opposition to nitrate the total ban on the use of nitrite in meat curing seems to be neither necessary nor justifiable in view of the present state of knowledge. The regulatory status of nitrite and nitrate in many countries is still somewhat tenuous and thus the research for alternative preservatives in cured meat countinues to find supplementary antimicrobials able to assure safety from botulism.

ASCORBATE AND ERYTHORBATE

These reductants react with nitrite to give nitric oxide, thus fastening development of the pink-red colour in cured sausages. Only sodium ascorbate and erythorbate (isoascorbate) are used in practice since ascorbic and isoascorbic acids react directly with the nitrite. Sausage emulsions containing ascorbate or erythorbate may be heat treated immediately after stuffing and a uniform red colour results throughout the product. Ascorbate apparently rapidly reduces metmyoglobin to myoglobin and, secondly reacts with nitrite to produce nitric oxide more efficiently. There are a number of other curing adjuncts which accalerate curing reactions.

SUGAR

Sugar is added to meat as an adjunct to counteract the salty taste, to give flavour and to serve as a substrate for bacterial

acid production in dry and semidry sausages. Sugar acting with the amino acids produce browning products which contribute to the colour and flavour of the product. Dextrose and d-glucose are employed in sausages at levels of 0.5 to 2.0 percent or even more. Occasionally, saccharose and maltose are also used in processing. The high sugar level in meat products is unusual for the average European or American but quite acceptable or pleasing to many Asians.

Corn syrup and corn syrup solids are often used instead of sugar; they are composed of a mixture of dextrose, maltose and dextrans whose relative quantity ratios are dependent upon the degree of starch saccharification.

PHOSPHATES

Phosphates have wide application in the meat processing industry. They include sodium tripolyphosphate, tetrasodium

pyrophosphate, sodium hexametaphosphate, sodium acid pyrophosphate, disodium phosphate etc..

Alkaline phosphate salts (sodium tripolyphosphate and tetrasodium pyrophosphate) elevate the pH of meat, thus improving its water-holding power. The acid reacting phosphates (alkali-metal salts or orthophosphoric acid and pyrophosphoric acid), on the contrary, lower the pH.

Polyphosphates act as buffers; they sequester cations and raise the ionic strength of the solution. Tetrasodium pyrophosphate interacts directly with actomyosin dissociating it into myosin and actin. Sodium tripolyphosphate has a similar effect, but is active after a short delay for enzymatic hydrolysis to tetrasodium pyrophosphate, while sodium hexametaphosphate does not interact at all. The actin and myosin, dissociated by tetrasodium pyrophosphate and sodium tripolyphosphate, are then solubilized by salt and thereby their water binding capacity is

enhanced. During heat coagulation of highly solubilized protein, the water is immobilized in the pores of formed gel structure.

Although both sodium tripolyphosphate and tetrasodium pyrophosphate are superior to all other phosphates, sodium tripolyphosphates have a higher solubility and are less prone to form insoluble precipitates. Sodium acid pyrophosphate in particular is often utilized in sausages. The permissible maximum concentration of residual phosphates in meat products is set at 0.5 percent.

Phosphates retard development of oxidative rancidity in meat products.

COLOURING AGENTS

Colour is a very important attribute of meats and is subject to great changes during processing. Therefore, the addition of

artificial dyes or natural pigments is often required to make meat products attractive to the consumer. However, artificial colouring of sausages is not usually permitted. Meat, particularly beef, contains enough natural red pigment so any addition of artificial colour is not technologically justifiable.

SPICES

It is no longer economically justified for the large-scale sausage manufacturer to blend flavouring raw materials in order to achieve consistent flavour levels in his sausage product. On the other hand, for the small-scale sausage manufacturer it is essential to know how to select, use and store spices and to be acquainted with their flavour profiles.

Flavour preferences differ considerably not only from region to region and from one country to another but also within the same country. These preferences should receive serious attention by

any local small-scale manufacturer not only because of their direct impact on food habits and expectations of his sausage consumers but also because of their intrinsic value to the identity of his products and because of their possible interference with modern sausage industry experience.

Any change the sausage manufacturer makes in his methods of processing can necessitate adequate modification in his spice formulations. Any new method of smoking or cooking may require spice formulation adjustments. A switch of fresh meat to frozen or of lean trimmings to those containing more fat or of local meat to imported may also render necessary a change in spice formulation. New trends in food marketing, new tastes in changing patterns of food habits and life style are also giving rise to new demands for flavouring changes.

Spices embrace an assemblage of true spices, herbs and vegetable bulbs. The term “true spices” usually refers to genuine

natural spices that include dried rhizomes, barks, flowers or their parts and fruits or seeds of different plants, principally grown in tropical and subtropical regions, containing aromatic and pungent substances and used for seasoning meat products (Table 1).

Table 1 ENGLISH AND LATIN NAMES OF THE MAJOR TRUE SPICES

Part of plant	English (Latin) name
Rhizome	ginger (<i>Zingiber officinale</i> Rosc.); curcuma (<i>Curcuma longa</i>);
Bark	cinnamon (<i>Cinnamomum zeylanicum</i>, Bl.); sweet orange and lemon (<i>Citrus medicus</i>);
Flower	capers (<i>Caparis spinosa</i>); cloves (<i>Eugenia caryophyllata</i> Thumbe); lavender (<i>Lavandula officinalis</i> Chaix); mace (<i>Myristica fragrans</i> Houtt); saffron (<i>Crocus sativus</i>); tarragon (<i>Artemisia</i>

	<i>dracunculus</i>);
Fruit seed	anise (<i>Pimpinella adisum</i>); allspice (<i>Pimenta officinalis</i> Lindl.); caraway (<i>Carum carvi</i>); cardamom (<i>Elettaria cardamomum</i>); chili (<i>Capsicum frutescens</i>); coriander (<i>Coriandrum sativum</i>); cumin (<i>Cuminum cyminum</i>); dill (<i>Anethum graveolens</i>); fennel (<i>Foeniculum vulgare</i> Lindl); fenugreek (<i>Trigonella fenumgraecum</i>); juniper (<i>Juniperus communis</i>); mustard (<i>Sinapis alba and Brassica nigra</i>): pimento see <i>allspice</i>).

Herbs are dried leaves of mostly temperate climate plants that have a distinctive flavour and aroma and which are used as spices to season meats and meat products (Table 2). Onion (*Allium sativum*) and garlic (*Allium cepa*), originate from vegetable bulbs and are widely used in meat product manufacture.

Table 2 ENGLISH AND LATIN NAMES OF MAJOR HERBS

English	Latin
Basil	<i>Ocimum basilicum</i>
Celery	<i>Apium graveolens</i>
Lovage	<i>Levisticum officinale</i>, Koch
Marjoram	<i>Origanum</i> spp.
Mint	<i>Menta piperita</i>
Mugwort	<i>Artemisia vulgaris</i>
Oregano	<i>Lippia</i> spp.
Parsley	<i>Petroselinum crispum</i>
Rosemary	<i>Rosmarinus officinalis</i>
Sage	<i>Salvia officinalis</i>
Savoury	<i>Satureja hortensis</i>
Sweet bay	<i>Laurus nobilis</i>
Thyme	<i>Thymus vulgaris</i>

Spices are variable in quality due to a complexity of varying factors (origin, climatic conditions, methods of collection, storage conditions etc.), influencing the flavouring picture. The large-scale sausages manufacturer can correct the flavour, colour and other quality characteristics of his spices through either control in his own laboratory or specifying his requirements to the spice processing company. The small-scale sausage manufacturer, in turn, cannot specify his requirements to his local spice producers, thus he is obliged himself to find the solution to his problems.

Spices are used either in natural form or as an extractive. Natural spices can be utilized whole but usually they are previously ground. Extractives include essential oils and oleoresins. Although spices are most commonly used in their natural form, extractives are becoming increasingly popular.

Natural spices.

Natural spices consist of intact plant parts, dried, cleaned and graded, and spices reduced to various degrees of comminution of breaking, granting, grinding, chopping or milling.

The main spice components are flavour-bearing essential oils which are deposited in special tightly protective cell structures. This is the reason why natural spices are characterized by an exceptionally long shelf life, and why the strength of a spice cannot be expressed by weight but rather in the percentage of essential oils it contains. Particle reduction of natural spices favours the process of flavour release. Standard ground spices produced today by major spice processors vary usually in granulation from 0.3 to 1 mm, but microground spices have a particle size of about 50 micrometer (0.05 mm). Finely pulverized spices liberate their essential oils more readily than intact spices. In small-scale sausage manufacture it is advisable to grind spice fresh when needed. Ground pepper loses potency more rapidly than most spices and it is recommended to take extra care that it

is fresh.

Natural spices are particularly used for semidry and dry sausages.

Essential oils.

Essential oils are volatile spice components extracted by steam distillation. They are basically mixtures of terpenes, sesquiterpenes and other hydrocarbons, various alcohols, ketones, aldehydes, phenols, and a small amount of different residues. The terpenes and sesquiterpenes are easily oxidized and, therefore, terpenless oils are increasingly popular. Essential oils are too concentrated for direct addition to a sausage emulsion.

Oleoresins.

Oleoresins are viscous resinous materials produced by solvent

extraction of ground spices; they consist of both volatile and non-volatile compounds. Oleoresins also undergo further processing to improve their solubility and adapt their strength for immediate use in sausage manufacture. Oleoresins are strong but they often lack the subtlety of flavour derived from natural spices.

Soluble spices or liquid forms of extractives.

Essential oils or oleoresins can be both water-dispersible and oil-soluble.

Dry spices or dry forms of extractives.

Essential oils and oleoresins are also available in spray-dried (encapsulated) and dry soluble forms which are often recommended in sausage making.

If the essential oils or oleoresins are evenly distributed in an

edible gum solution and dried, particles of extractives are encapsulated by a layer of fine gum and a new form of seasoning is obtained.

In the preparation of dry soluble spices, the extractives are dispersed into a salt-or dextrose-medium. The dextrose or salt is easily dissolved in water and this fact helps in the uniform distribution of extractives in the sausage mix.

Soluble spices are frequently used with cooked sausages because they are low in tannin, flavones and anthocyanin which may darken when heated. Therefore, the colour of sausages is somewhat brighter when soluble rather than natural spices are added.

Spice blends.

Spice blends can be either a mixture of natural spices, of natural

spices and extractives (preparations) or combinations of extractives themselves. Each of them may be produced with or without the addition of some carriers or stabilizers such as sugar, dextrose, salt, starch, some proteins etc. They are marketed in batch-packaged units suitable for direct use in sausage production.

The proper formulation of individual spices for different kinds of sausages is of utmost importance. Although, it is absolutely necessary to avoid any superiority in strength of an individual spice except for specific cases, most sausage spice formulations are composed of basic and supplementary spices. A good sausage spice mixture should normally have the individual spices so well balanced in strength that a uniform reproducible product is obtained, giving the sausage a well-balanced rounded full flavour. Spices of equal quality and strength should always be used and, after any change in their quality, the spice mixture must be reformulated.

The most important natural spice in sausage making is pepper. It blends well with salt and sage and a series of other spices. There is no great difference in flavour between black and white pepper but black pepper is more noticeable in the sausages appearance. Salt and pepper form a flavour basis for many traditional sausages.

There are also other traditional spices for many sausages. Apart from pepper, thyme and mustard as well as savoury are also popular in numerous sausages; the addition of thyme is often practised in sausages containing a distinctive amount of added cereals. Anise is used in spice formulations for many raw sausages and mortadellas, and cinnamon in spice blends for bologna and many cooked sausages; bay leaves and ginger are important spice components for pork sausages. Garlic is combined with other spices for smoked sausages, while marjoram is often found in spice formulations for different sausages as a supplementary flavouring agent. Onion is

generally utilized in cooked sausage production. Nutmeg and mace are chiefly supplementary spices in blends for some cooked emulsion-type and even raw sausages. The same is almost true for cardamom and rosemary. Tarragon and cumin combine well with basic components in poultry sausage spice formulations. Lavender and rosemary are often either basic or supplementary spices for sausages made from mutton or with a high fat content. The total amount of spices added in a sausage mixture varies widely from 0.7 to 2 or more percent.

A fairly recent substance used in seasoning foods is monosodium glutamate. It fortifies and intensifies other flavours, but first of all it enhances the flavouring components of the meat itself. Sugars blend well in many spice mixtures and are often used in flavouring combinations.

Today there is an increasing trend in sausage spice formulations to combine several basic and a number of supplementary spices

in such proportions to eliminate the preponderance of any single flavour, thus creating an overall harmonious flavour. Tables 3, 4, 5 and 6 list the most important spices and their usual optimum

Table 3 BASIC AND SUPPLEMENTARY SPICES USED IN SEMIDRY AND DRY SAUSAGES

Spices in formulation (in grammes per 1 kg)			
	Basic		Supplementary
A	dextrose (2–3)	A	allspice (0.3–3.0)
	sugar (2–4)		Jamaica rum
	pepper (1–2.5)		cardamom (0.3–0.5)
	red pepper (0.3–0.5)		sage (0.3)
	mace (0.4–1.0)		
	dry starch syrup (2–5)		
B	mustard (1.0–2.0)	B	rosemary (0.3)
	caraway (0.2–0.5)		cloves (0.3–0.5)

	garlic salt (0.5)		marjoram (0.2–0.3)
	coriander (0.3–0.5)		
	anise (1.0–2.0)	C	glutamate (0.1)
			lavender
			ginger (0.1–0.3)
			fenugreek (0.5–1.0)

A - very frequent use;

B - frequent use;

C - occasional use

Table 4 BASIC AND SUPPLEMENTARY SPICES USED IN FINE CUT EMULSION-TYPE SMALL-DIAMETER SAUSAGES

Spices in formulation (in grammes per 1 kg)			
	Basic		Supplementary
A	white pepper (2.1–2.5)	A	cardamom (0.3–0.5)
	black pepper (2.0–2.5)		allspice (0.2–1.0)

	glutamate (0.1)		cumin
	nutmeg, mace (0.2–0.4)		
	meat broth (0.5–6.0)	B	coriander (0.2–0.3)
			juniper (0.2)
			marjoram (0.2–1.0)
B	garlic (0.2–0.4)		onion (2.5)
	red pepper (0.5)		ginger (0.3–0.5)
	chili (0.01)		
	caraway (0.2–0.5)	C	celery salt (2.0)
	lemon bark (0.1–0.3)		sugar
	dry starch syrup (2.0)		parsley (0.02)
			cloves (0.3–0.5)

A - Very frequent use;

B - frequent use;

C - occasional use

Table 5 BASIC AND SUPPLEMENTARY SPICES USED IN EMULSION-TYPE LARGE-DIAMETER SAUSAGES

Spices in formulation (in grammes per 1 kg)			
	Basic		Supplementary
A	black pepper (1.0–2.5)	A	ginger (0.2–0.3)
	nutmeg, mace (0.3–1.0)		red pepper (0.3–1.0)
	garlic (0.1)		allspice (0.2–0.3)
			rosemary (0.1–0.3)
B	pistachio (10.0)		marjoram (0.5)
	sage (0.2–0.5)		oregano (0.3–0.5)
			glutamate (0.1–0.2)
		B	caraway (0.25–1.0)
			chili (0.02)
			cardamom (0.2)
			mustard (1.5)
			onion (6.0)

		C	lemon bark (0.1)
			cinnamon (0.2)
			parsley (0.2)
			cumin (0.2–0.3)

A - very frequent use;

B - frequent use;

C - occasional use

Table 6 BASIC AND SUPPLEMENTARY SPICES USED IN COOKED SAUSAGES

Spices in formulation (in grammes per 1 kg)			
	Basic		Supplementary
A	onion (10.0)	A	ginger (0.3–0.5)
	marjoram (0.5–2.0)		thyme (0.1–0.2)
	white pepper (2.0–4.0)		rosemary (0.1–0.3)
	meat broth (2.0)		savoury (0.2)

	sugar (2.0–4.0)		basil (0.2–0.3)
	cloves (0.2–0.4)		
	black pepper (2.0)	B	vanilla (according to taste)
			nutmeg (0.3–1.0)
B	allspice (0.5)		cinnamon (0.05–0.2)
	cardamom (0.2–0.5)		anise (0.2)
	tomato concentrate (20.0)		dill
	glutamate (0.1)		
	nutmeg (0.3–1.0)	C	lemon bark (0.1)
	chili (0.01)		mace (0.5–1.0)
			curry (0.3)
			celery salt (0.3–2.0)
			coriander (0.3–1.0)
			caraway (0.3–0.6)
			red pepper (0.5–1.0)

		parsley (0.1–0.3)
		sweet bay
		lavender
		mugwort
		fennel

A - very frequent use;

B - frequent use;

C - occasional use

Sterilized spices.

Natural spices are sometimes contaminated with an important number of microorganisms. However, the sterilization of spices is difficult. On the other hand, as the total spice added to various type of sausages does not usually exceed 1 percent, the spice contribution in the sausage total bacterial count is, as a rule, of minor importance. Spices sterilization by ethylene oxide gas

fumigation, which has frequently been used, is not without risk from the health point of view. Nevertheless, careful attention in selecting and preparing natural spices is normally sufficient to obtain a reasonable shelf life of the final product. Extractives are microbiologically advantageous because they are free of microbial contamination.

Other spice properties.

Certain spices act as antioxidants retarding the rate of oxidative changes in sausages (viz. onion, rosemary, sage, thyme, ginger, black pepper, garlic, cloves etc). Some spices contribute to microbial contamination of sausages and others have a limited preservative effect. Cinnamon, onion, garlic and a number of other spices are able to inhibit proliferation of distinctive microorganisms. Spices in raw sausage fermentation have an active influence in the control of bacterial development.

Storage.

Spices (whole or ground, natural or extractives) can be stored without too much loss of flavour if tightly sealed and kept in a cool, dark and dry place.



SAUSAGE CASINGS

While metal and plastic moulds are used to shape loaves and some other comminuted meat products, natural and artificial casings are used as forms and containers for sausages. The casings bind and protect the delicacy of the sausage mixture;

they regulate contraction and expansion of the sausage.

1. NATURAL CASINGS

Sausages have historically been manufactured in natural casings. Natural casings are almost exclusively prepared from different parts of the alimentary canal of pigs and ruminants. Pig casings are derived from the stomachs, small intestines (pig casings, smalls or rounds), large intestines (caps and middles) and terminal straight end of the large intestines (bungs). Cattle casings are obtained from the oesophagus (weasands), small intestines (rounds or runners), caecum (bungs), large intestines (middles) and urinary bladders. Only the small intestines of sheep are used for sausage casings.

The walls of the entire intestinal tract consist of four distinct tissue layers: mucosa, submucosa (rich in collagenous fibres), circular and longitudinal muscle layers and serosa or external

layer.

PIG CASINGS

The total length of the pig's large and small intestines is about 19 to 24 m.

Pig stomachs (or “maws”).

After separation from the adhering fat, the stomachs are further processed in two ways. If the stomachs are to be incorporated into the sausage, they are scalded and well cleaned. If they are to be used as casings, only a small opening is made through which they are cleaned by flushing and then kept in salt until used. Pig stomachs are used for stuffing head cheeses etc.

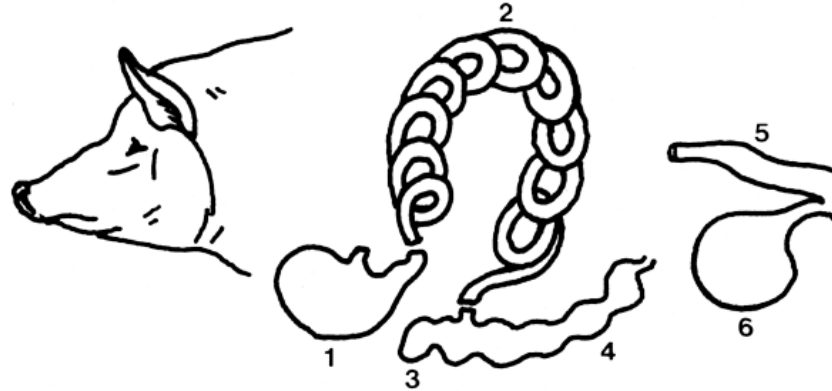


Fig. 19 HOG CASINGS

- 1. - stomach,**
- 2. - rounds,**
- 3. - cap,**
- 4. - midles,**

5. - bung,

6. - bladder

Small pig casings (pig rounds).

The pig's small intestines have an average length of 15 to 20 m and vary in diameter and strength according to the breed of animal and type of feed consumed. Today fresh cleaning methods of processing casings without fermentation are adopted.

After removal of fat and mesentery (“running”), cleaning and removal of the intestinal contents (“stripping”) by machine or by hand, the intestines are first crushed between rollers of a mucous crusher and then slimed, i.e. passed between a set of rollers or strippers to remove mucosa and other unnecessary

layers of the intestinal wall (both muscle layers and serosa), leaving only the submucosa. The slimed intestines are graded (inflated by air or water), salted with 40 percent salt and kept until used.

The intestines of the pig (and particularly those of sheep) have long been processed by fermentation. The process of fermentation enables their sliming by hand without using machines. The method is as follows: after being turned inside out, the casings are soaked in water at 20° to 24°C overnight or until the mucosa and muscle layers become adequately tender to allow their manual removal (“sliming”). Such treatment causes the processed pork rounds to be characteristically composed of only the submucosa layer; the connective tissue-rich submucosa is not loosened and the final product is of good mechanical strength.

Pig rounds are packed in hanks of 100 yards (300 feet or 91.4m),

consisting of 15 to 20 pieces, measuring about 18 ft each (5.5 m). Pig casings are graded according to diameter as narrow (28 mm and under), narrow medium (28 to 32mm), regular medium (32 to 35 mm), medium (35 to 38 mm), wide (38 to 42 mm) and extra wide (42 mm and over). Pig casings are used for fresh sausages, chorizos, frankfurters etc.

Pig caps (caecum) and pig large intestines (middles).

After separation from the fat, the large intestines are stripped of their contents, flushed out with water, turned over, chilled in brine overnight, stripped free of mucosa and serosa, leaving the submucosa and both muscle layers, and finally salted. The industrial term for the processed caecum is “cap”; the first portion of the large intestines is not utilized as sausage casings and the middle portion of the pig's large intestine is known as “middles”.

The pig's large intestines are also used for preparations as chitterlings or filler meat. In sausage making, they are used for stuffing liver sausages, some salamis etc.

Pig bungs.

After the bungs (terminal end of large intestines, i.e. the ends of the intestinal tract starting from the anus) are pulled free from their setting, they are stripped under a spray of water which washes away the contents. The bungs are soon afterward slimed, inflated for grading and thoroughly salted.

Pig bungs are 1 to 1.5 m in length. Their diameters vary from about 30 to more than 50 mm. Pig bungs are primarily used for liverwurst, cervelat, dry sausages etc.

Pig bladders.

Pig bladders are emptied, trimmed free of fat, turned over and

bleached in ice water or brine for a period of time. They are preserved by salting or inflated by air and dried.

BEEF CASINGS

The total length of the small and large intestines is about twenty times the length of the body in cattle.

Weasands (oesophagus of cattle).

After the musculature is removed from the outside the weasands are washed turned inside out, cleaned, inflated with air, graded and dried. They are used for large sausages; their length varies from 45 to 60 cm and over

Beef rounds (“runners”).

The small intestines of cattle have an average length of 40 m the average diameter is 5 to 6 cm.

The rounds are turned inside out and slimed; the mucosa and serosa are removed from the intestines leaving the submucosa and both smooth muscle layers which, in beef intestines are much thicker than in pig intestines. After submerging in water and washing, rounds are calibrated, tied and salted. Salted rounds are marketed in sets not less than 100 yards (91.4 m) each set containing a maximum of five pieces. Beef rounds are used for stuffing ring sausages, all beef sausages in Near East countries etc.

Beef rounds are classified in wide (38mm and over), medium (35 to 38 mm) and narrow (35 mm and under).

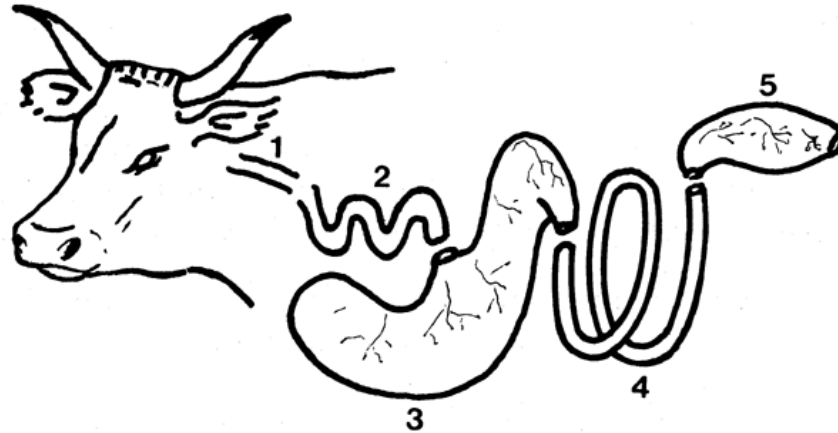


Fig. 20 BEEF CASINGS

- 1. - weasand,**
- 2. - rounds,**
- 3. - bung,**

4. - middles,

5. straight casing

Beef bungs.

The caecum or blind gut has an average length of 75cm and diameter of 12 cm. Caecums are substantially processed in the same way as beef middles. Beef bungs are used for stuffing cooked sausages, capicola, large bologna etc. Their diameter varies from 76 to 102 mm.

Beef middles.

The middles are separated from the ruffle, flushed out with water, trimmed free of fat, turned over, slimed and salted. Beef middles also include the “straight” casing and are packed in sets each measuring about 17 m 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.

Beef bladders are washed, turned over and either salted or inflated with air and dried. They are used for mortadellas, different sausage specialities etc. Beef bladders are usually graded in large, medium and small sizes.

SHEEP AND GOAT CASINGS

The small intestines (sheep or goat small casings or rounds) are pulled free of the adhering fatty tissue, stripped free of their contents, immersed in water (10°C) and fermented or directly slined by machines. After the removal of the mucosa, serosa and both muscular layers, the casings are chilled, inflated for

grading, salted and stored.

Sheep casings are packaged in hanks (100 yards or 91.4 m) and may be extra wide (25 mm and up), wide (22 to 24 mm), medium (20 to 22 mm), narrow-medium (18 to 20 mm) and narrow (16 to 18 mm). Sheep casings are primarily used for fresh frying sausages and for frankfurters, wieners, chipolatas, etc. Sheep fore-stomachs are used for haggis and some other meats and fancy meat specialties.



Fig. 21 GOAT AND SHEEP CASINGS

1. - rounds,

2. - cap,

3. - straight casing

SEWN CASINGS

Sewn casings are made by sewing beef middles and small pig bungs together. Special sewing machines are marketed for this purpose.

Sewn beef middles are made by sewing two or more pieces of beef middles together. They are used for stuffing different fresh or semidry salamis, bologna etc. They are made in different diameters with stuffing capacity from 0.7 to 2 kg.

Sewn pig bungs are usually manufactured in about 70 cm length with a diameter of 5.5 to 7 cm resulting in a stuffing capacity of 1.8 to 2 kg. Larger sizes of sewn pig bungs are also sometimes made by sewing more than two pig bungs together.

PREPARATION OF NATURAL CASINGS FOR STUFFING

All casings must be inspected before being used. The surface of

all casings should be completely free of any remaining adhering fat. All natural casings, except sheep casings, before being used should be turned inside out, washed and trimmed of fat. Salted casings should be soaked in water for desalting; dried casings are watered for softening. Any casing that is left over the same day must be resalted.

2. ARTIFICIAL CASINGS

Artificial casings offer a uniform cylindrical shape and the choice of any specific diameter and suitable tensile strength as well as resistance to damage. They are filled uniformly and, after filling, sausages can be linked by machine or by hand into required lengths. The artificial casings are made from cellulose, collagen, plastic and other materials.

Cellulose casings are manufactured in different sizes, ranging from 1.5 to 15 cm; their important advantage is size uniformity.

Cellulose casings are not soaked in water prior to stuffing. Small diameter cellulose casings are produced in long lengths, but large diameter fibrous cellulose casings are manufactured separately. Fibrous casings, designed as special tough casings, are reinforced with cellulose fibres having great strength as well as many of the attributes of natural casings; they take print well. Special types of fibrous casings are the so-called easy-release and plastic-coated moisture-proof casings. Dry sausage fibrous casings are especially developed for semidry and dry sausages.

The interior surface of the cellulose casings can contain a water soluble dye which colours the sausage surface during heat processing. Coloured cellulose casings in cream, yellow, black and other colours are used for the cooked type of sausage. The stuffed sausages have a smooth surface and the nature of the casing offers hygienic protection for the sausage content.

Cellulose and other artificial casings are not as permeable to

smoke as animal casings. Stuffed cellulose casings cannot be pricked to expel air unless a red hot needle is used. After the small casings are stuffed, they are twisted in the same way as natural casings but with large casings the open end is twisted and then tied. Cellulose casing for small diameter sausages should be peeled from the product by the sausage manufacturer.

Regenerated collagen casings have many advantages and may be edible or inedible. Edible collagen casings are stronger than natural casings. The inedible collagen casings must be removed from the product before consumption.

Many types of plastic casings are available today. They are usually impermeable to moisture and are sold under different names. The use of special grade smooth polyethylene casings is another development in sausage production. Polyethylene casings take print exceptionally well and permit an attractive presentation.

Impregnated cloth casings and other artificial casings are also used for stuffing sausages.

3. STUFFING, AND THREAD AND CLIP CLOSURES

The meat emulsion is extruded through the stuffing horn into natural or synthetic casings mounted over the end of the stuffing horn.

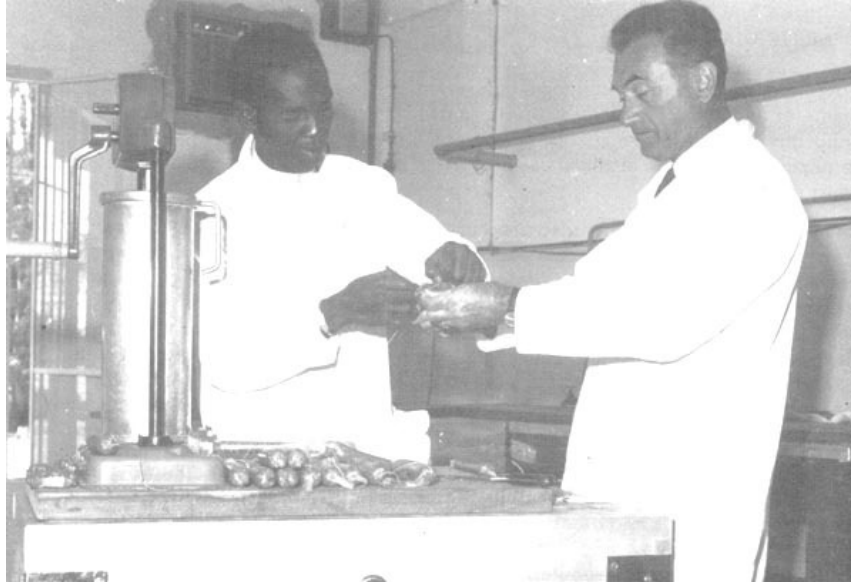


Fig. 22 HAND LINKING OF SAUSAGES IS A SKILLFUL OPERATION

The large diameter casings are tied at one end, placed on the stuffing horn and the sausage emulsion is ejected through the horn. The machine operator has to hold the casing on the

stuffing horn with one hand to restrict the flow off the horn while operating the clipping or tying machine with his other hand. For linking small diameter sausages 2 to 4 ply cotton thread is usually recommended while for tying very large diameter sausages 10 to 16 ply thread may be necessary.

Cellulose casings for large sausages are first tied or clipped dry, soaked prior to stuffing and then they are tied wet for the second closure. Fibrous casings are clipped wet or dry at both ends.



FRESH SAUSAGE PRODUCTION

Fresh sausages are not heat treated and they are sold in a raw state. In principle, fresh sausages are not cured. Fresh sausages actually comprise the mixtures of meats, fat and spices stuffed into casings with the intention that the consumer himself cooks them prior to serving. In many countries they are manufactured on request in butcher shops.

The basic raw materials used in fresh sausage manufacture are pork and beef, including their trimmings. Veal is also often processed, especially for higher quality products. Meat and fat are generally coarsely ground. The ratio of lean to fat has a decided bearing on the quality of the product, particularly in controlling the shrinkage that occurs during cooking. The leaner formulae show less shrinkage than formulae with more fat. The addition of a small amount of water or milk (3 to 5 percent) facilitates the stuffing operation. Occasionally, however, dry or sticky meat can cause stuffing and linking problems which can be avoided by the addition of more water. A meat temperature of

2 to 4°C at stuffing and good fluid properties of the meat mass are the best conditions for preparation of fresh sausages for stuffing. If any binder is used at all, its amount should not be more than 1–3 percent of the weight of the meat. A mechanical mixer is highly desirable for larger quantities.

Fresh sausages are normally stuffed in pig or sheep casings. The casings are washed with water prior to being placed upon the stuffing horn. They are filled to maximum capacity. Medium size casings are preferably used for pork sausages, especially if they are stuffed into links. Narrow casings are more suitable for fresh beef sausages. The stuffed casings are divided by linking into shorter units. This is carried out by giving the stuffed casing a twist at regular intervals. The sausage units are of various length depending upon local market demands. After stuffing and linking, fresh sausages should be dried at room temperature for a short time and chilled rapidly. Chilling should be done by hanging sausages in a chiller.



**Fig. 23 GRINDING OF BEEF FOR SAUSAGE PRODUCTION
(Photo taken in the Food Research and Development Centre at
Serdang, Malaysia)**

The most common seasonings are salt, dextrose, pepper, mace, red pepper, sage, chili, garlic, ginger, lemon bark, cinnamon, onion, cumin, monosodium glutamate, celery salt etc. The

binders, which provide satisfactory control of shrinkage in cooking, are wheat flour and rusk and isolated soy protein, either alone or in combination with wheat flour. The rusk should have a good colour, be free of any odour, and be able to absorb moisture. The rusk is added in the cutter or mixer either in a dry or presoaked state. Other edible binders, such as nonfat milk solids or soy protein concentrate, fail to provide the necessary control of shrinkage in the consumer's kitchen.

The point which is of utmost importance to enhance the keeping life and to improve the quality of the product is that all fresh sausage operations must be carried out quickly and in strictly hygienic conditions. All equipment must be scrupulously clean.

Sausage products in this group include fresh pork and beef sausages.

Use of prerigor meat in fresh sausage production.

In many tropical and subtropical countries, fresh sausages are often produced from warm slaughtered or prerigor meat. This practice can only be encouraged since prerigor meat is an excellent raw material for these products. While the high water holding capacity of prerigor meat improves the structure and yield of coarse ground fresh sausage, the reduced myoglobin state is of even greater value. Typically, the colour of fresh sausages, made from chilled meats, fade from a red colour to a brownish-grey colour in a short time exposed to light, salt and oxygen. Fresh sausages manufactured with prerigor meat will maintain a red colour in the presence of salt and light for up to 5 to 6 days of refrigerated storage and some weeks with frozen storage.

If prerigor meat is used in making fresh sausages, considerable savings in refrigeration costs may be realized. Because of contamination potential, very strict sanitation procedures are required. Handling hot meat is essentially different from handling

chilled meat and this practice is well known in tropical and subtropical countries.

Shelf life of fresh sausages.

Fresh sausages are more perishable than other types of sausages and should be handled with special care. Fresh sausages deteriorate relatively rapidly due to both microbial spoilage and oxidative rancidity. Fresh sausages must be kept in a refrigerated room at a temperature close to 0° to 4°C. Fresh sausage storage life at refrigerator temperatures above freezing is usually 2 to 4 days. Freezing protects the product successfully against bacterial spoilage but not against oxidative rancidity, assisted by the catalytic activity of the salt.

Exposure of the fresh sausages to temperatures between 20° and 40°C is detrimental to the product which may not be immediately visible. The practice of mild smoking of some kinds

of fresh sausage will not give longer protection. The proper circulation of air in a fresh sausage storage room is a subject requiring considerable study for each individual installation. Most processors consider that a moderate circulation of air will satisfactorily extend the shelf life of a product but if the air circulation is too rapid, an excessive shrinkage will occur associated with surface skin formation.

Air humidity in a storage room has much if not more influence than air circulation on surface spoilage, mould, shrinkage, and the appearance of fresh sausages. Air circulation in a sausage storage room must be kept reasonably dry. A humidity of 75 to 80 percent seems high enough with a temperature of 6° to 8°C to prevent excessive loss of moisture and low enough to keep the product for some days and to avoid the formation of mould.

In fact, one of the chief difficulties encountered in sausage storage is moulding. This can be controlled to some extent by

practising extreme sanitation in all operations and by control of stocks carried by retailers. In cleaning operations, a final wash of sodium hypochlorite is recommended.

Another difficulty associated with fresh sausage storage is the oxidative rancidity, particularly if sausages are kept in a frozen state or made from previously frozen raw materials. This phenomenon can be controlled, to a limited extent, by practising extreme low air circulation in the storage room, by avoiding processing of long stored frozen meats and fats, by the use of antioxidants and by proper selection of spices. A way to slow down rancidity is to avoid excessive dehydration of the product. The use of prerigor meat is also a method of reducing excessive dehydration and oxidative rancidity. Insofar as antioxidant addition is concerned, both the fat-soluble type (butylated hydroxy anisol, butylated hydroxy toluene) and the water-soluble type (ascorbic acid, citric acid) are effective.

FRESH SAUSAGE FORMULATIONS

Different techniques and formulae are used in manufacturing fresh sausages in various countries. The following fresh sausage formulae and methods of preparation have been selected, among many others, and submitted primarily as a guide. Numerous other formulae, generally similar, will give satisfactory results if recommended procedures regarding processing and handling are fully respected. The sausage formulations which follow require the addition of from 2 to 3.0 percent of a binder to any fresh pork sausage formula and 1 to 2 percent of binder to any fresh beef sausage formula. Spice levels as indicated in the following formulae may be increased slightly if it is determined that flavour is lost during precooking. The addition of extra dextrose or corn sugar to the spice formula is helpful in browning the sausage rapidly on re cooking.

In developing any product, the manufacturer must consider these

formulations only as a basic suggestion and he must spend considerable time in testing, modifying and adjusting them according to local preferences and conditions.

1. FRESH PORK SAUSAGES

Fresh pork sausages are a very popular breakfast item in many European and American homes as well as restaurants and throughout the years have been a leading pork product.

This kind of sausage consists only of ground seasoned pork and its manufacture involves only a few operational steps. Seasoning formulae vary widely with particular market and regional preferences, but generally speaking, there are two seasoning extremes: a sage and sugar flavour and, on the other hand, a hot seasoning.

FORMULATION No. 1

Basic ingredients for 100 kg

90 kg fresh pork trimmings (60 to 70% lean)

10 kg fresh pork backfat

Characteristic seasoning formula per 1 kg

a. 18.0 g salt

1.5 g white pepper (ground)

1.0 g mace

2.0 g sage

1.0 g sugar

0.4 g savoury

b. 18.0 g salt

2.4 g pepper

1.1 g sage

1.5 g ginger

0.02 g chili

0.2 g monosodium glutamate

Casing

Pig rounds: narrow (under 28 mm)

FORMULATION No. 2

Basic ingredients for 100 kg

60 kg side pork (belly)

40 kg lean pork

Characteristic seasoning formula per 1 kg

18.0 g salt

2.0 g pepper

1.0 g mace

1.0 g ginger

0.4 g cardamom

1.0 g lemon bark powder

0.1 g fresh garlic

Casing

Pig casing: narrow (26 to 28 mm)

Processing and handling

Pork is sprinkled with the seasoning mixture before grinding. The pork trimmings are put first through a 13 mm plate and then through a 5 mm plate grinder and seasoning is added and mixed. If Formulation No. 1 is applied, 2 to 3 percent of milk may be used. The mixture is stuffed into previously soaked casings.

It is considered that a highly acceptable fresh pork sausage can be produced by formulating the product to a 35 percent fat level.

2. FRESH BEEF SAUSAGES FOR GRILLING

These sausages are by far the most widely manufactured restaurant or grill sausages in some Arab countries. They are often sold in small butcher shops where they are also produced on request in desired qualities. It is almost impossible to give a standard recipe for fresh beef sausages for grilling since selection and proportions of individual ingredients used depend upon the type of meat available and a variety of other factors.

The use of cereal binders in this type of sausage is not a necessity but it sometimes occurs. Rusk or other binders used are added in the mixer or cutter either in a dry or presoaked state.

FORMULATION

Basic ingredients for 100 kg

85 to 90 kg lean beef or lean beef trimmings (one-third beef may be substituted by mutton, if desired)

10 to 15 kg selected beef or mutton fat

0.5 to 3.0 kg rusk is sometimes added to improve binding

2 to 3 kg salted water may also be added to facilitate stuffing

Characteristic seasoning formula per 1 kg

20.0 g salt

0.5 to 1.0 g red pepper

0.01 to 0.02 g chili

0.2 to 0.6 g cardamom

0.2 g ginger

0.1 to 0.5 g fenugreek

0.2 to 0.6 g sugar

Casings

Sheep or goat casings of different diameter: wide (22 to 24 mm), medium (20 to 22 mm), narrow medium (18 to 22 mm) and narrow (16 to 18 mm).

Processing and handling

The meat and the fat are run separately through the coarse plates of the grinder: meat through a 6 to 8 mm plate, fat through a 5 to 6 mm plate. Both types of grinded material are then mixed for a few minutes while the above-mentioned seasonings are added. The mixture obtained can be regrinded through a 5 mm plate and finally stuffed into presoaked salted goat or sheep casings.

The stuffed casings are generally divided in units by twisting. The length of sausage units or links varies widely but short links of 5 to 7 cm and long links of 10 to 15 cm are common lengths.

The finished sausage should be either immediately used in the kitchen or stored at 0° to 4°C for a maximum of two days.

3. CURRY BEEF-MUTTON SAUSAGES

This type of fresh sausage is often made on request in butcher shops. The basic ingredient formulation for this sausage varies considerably. The curry flavour must be pronounced.

FORMULATION No. 1

Basic ingredients for 100 kg

85 kg beef flank

15 kg beef fat (brisket fat, fat beef trimmings

or zebu boss¹ fat) or mutton fat (tail fat)

Characteristics seasoning formula per 1 kg

18.0 g salt

2.0 to 2.2 g curry powder

0.5 g sugar

2.0 g pepper

Casings

Goat or sheep narrow casings (16 mm) and collagen casings.

¹ A protuberant part on the theraco-cervical region of zebra cattle (the hump).

FORMULATION No. 2

Basic ingredients for 100 kg

a. 45 kg lean beef

35 kg lean meat or lamb

20 kg beef or mutton fat

- b. 40 kg lean beef**
- 20 kg mutton**
- 20 kg beef trimmings**
- 20 kg zebu boss fat, beef brisket fat
or mutton fat**

Characteristic seasoning formula per 1 kg

22.0 g salt (or to taste)

2.0 g curry powder

1.0 g red pepper

0.2 g cinnamon

Casings

Goat or sheep casings or edible collagen casings: narrow (under 18 mm) or very occasionally narrow medium (18 to 20 mm).

Processing and handling

The chilled meat is grinded through a plate having holes 10 mm in diameter. Then it is mixed in a mixer 2 to 3 minutes with the salt, curry powder and other spices and the mix is passed through a 5 mm plate. The stuffer is filled with mix and the mix tamped tightly to eliminate air pockets. Further handling of sausages is as described in the instructions for fresh sausages for grilling.

4. SAUSAGE-BURGER (Hamburger)

Technologically hamburgers are typical fresh beef sausages that are not stuffed in casings. However, stuffing hamburgers into appropriate casings may be advantageous for small scale manufacturers.

Hamburgers are made of ground seasoned beef, without addition of others meats. Prerigor meat is an excellent raw material for hamburgers and it should be removed as soon as possible from

the carcass and coarse ground through a plate having holes of 12 mm or even larger. Mixing with salt gives a product of high water binding capacity.

FORMULATION

Basic ingredients for 100 kg

85 kg fresh beef (flanks, shanks, necks etc.)

10 kg beef fat

Additional ingredients

3 to 5 kg sausage binder

1 to 3 kg ice

Characteristic seasoning formula per 1 kg

20.0 g salt

0.6 g monosodium glutamate

1.0 g ground white pepper

0.6 g sugar

onion - to taste

Casings

Cellulose casings of 60 mm in diameter.

Processing and handling

The meat should be thoroughly trimmed of fat and connective tissue. Normally meat is ground twice: once through a coarse plate (8 to 12 mm) followed by addition of the binder and after mixing, the second grinding is performed through a finer plate having holes of 2 to 4 mm in diameter.

The meat is mixed until the desired degree of binding is obtained. The mass is immediately stuffed into casings of about 6 mm in

diameter, then chilled or frozen as soon as possible. After freezing the sausage is cut by machine or by hand into slices (hamburgers) of the desired thickness.

If hamburgers are for immediate use, a binder may be added (egg, protein, starch), so the product may be more easily sliced and marketed or kept under refrigeration.

The keeping quality of frozen sausage-burgers is limited to 1 to 2 weeks. The use of soy protein as an extender is discussed under the heading “Nonmeat sausage ingredients”.

5. MERGUEZ (Mergès)

Merguez is an all-beef sausage that throughout the years has been one of the leading meat items served in all types of restaurants in many North African countries.

Various formulated ingredients, different qualities of raw

materials and different processing variables utilized in the production of merguez sausages affect the overall quality of this popular product.

Prerigor meat is an excellent raw material for merguez manufacture. There is not much doubt that in hot climatic conditions, the use of prerigor meat is associated with reduced microbiological load of the product and is in full accordance with local habits and customer resistance to chilled or frozen meats.

FORMULATION No. 1

Basic ingredients for 100 kg

50 kg lean beef

35 kg beef trimmings

13 kg brisket fat

2 kg ice

Characteristic seasoning formula per 1 kg

20.0 g salt 2.0 g red pepper (hot) 0.4 g garlic, fresh 5.0 g onion

Casings

goat or sheep casings: narrow (16 to 18 mm) and narrow medium (18 to 20 mm).

FORMULATION No. 2

Basic ingredients for 100 kg

75 to 80 kg lean meat

20 to 25 kg fat

Characteristic seasoning formula per 1 kg

20.0 g salt

11.0 g spice mixture containing 4 parts ground pepper, 2 parts chili powder, 1 part monosodium glutamate, 1 part fresh garlic and 1 part red pepper.

Casings

goat or sheep casings: narrow (16 to 18 mm)

Processing and handling

The fat is run through a 4 mm plate while the meat ingredients are ground through an 8 mm plate of the grinder. An alternative is chopping in the cutter (without previous grinding) and mixing with the spices, salt and ice for 1 to 2 minutes. The mixture is then stuffed into animal casings.

Merguez sausages are twisted at regular intervals, producing links of 4 to 7 cm lengths.



FERMENTED SAUSAGE PRODUCTION

The broad group of fermented or raw sausages includes a large number of products whose characteristic properties are partially or completely dependent on fermentative action of certain types of bacteria. The comminuted meat mass may be submitted to curing either prior to or after stuffing. The stuffed sausages are processed by smoking, drying and ageing which make a product entirely suitable for eating without further cooking.

The principle two subgroups of fermented sausages are semidry or quickly fermented and dry or slowly fermented (semifermented) sausages. There are both hard and soft types in

both subgroups.

SEMIDRY SAUSAGES

Semidry sausages differ greatly from dry sausages by their pronounced “tangy” flavour of forced fermentation resulting in lactic acid accumulation and a bulk of other products of fermentative breakdown. The addition of starter cultures for a number of semidry sausages is particularly successful.

Semidry sausages are usually stuffed in medium-and large-diameter natural or artificial casings. The length of production (smoking and fermentation) of these sausages depends upon their type but rarely exceeds several days.

The pH of semidry sausages is explicitly acid (4.8 to 5.2–5.4); although they are often finely chopped and spreadable, many of them can be cut in thin slices; their water content reaches 35

percent or more.

Semidry sausages are regularly smoked and only exceptionally slightly cooked by the heat applied in the smokehouse at various temperatures, mostly not exceeding 45°C and very occasionally rising to nearly 60°C for a strictly limited time; after smoking the sausages are usually air-dried for a relatively short time.

Semidry sausages usually contain an important proportion of beef. Their shelf life is surprisingly good due to low water activity, accumulation of acids and smoke compounds, counteracting the effect of lactic acid bacteria on spoilage microorganisms, etc. A high level of hygiene and the ability to perform dexterously all operations in the manufacturing process are basic prerequisites for the good keeping quality of semidry sausages. Semidry sausages have improved stability if stored in the chiller, protected from humidity rather than at room temperature.

This category of sausages is popular in many European countries and North America. As these sausages need only little refrigeration, they can be successfully produced in many subtropical countries.

The main sausages of this group are: summer sausages (with a series of varieties in many countries), different types of cervelats and metwursts, lebanon bologna (in USA), etc.

DRY SAUSAGES

The organoleptic and other properties of dry sausages depend not only upon the products of sugar bacterial fermentation but are also strongly influenced by biochemical and physical changes occurring during the long drying or ageing process. The use of starter cultures for this category of raw sausages is less successful than for the semidry varieties. The length of production, either with or without smoking, and drying periods

depends upon a multiplicity of factors, such as diameter and physical properties of casings, sausage formulation, choice and methods of preparing meat, conditions of drying etc. but overall processing time may require up to 90 days. The final pH of dry sausages is usually somewhat higher (5.0–5.5) than in semidry sausages, and it increases during the second part of this long ageing process.

Dry sausages are made from selected, mainly coarsely chopped, meat (some Italian salamis, some types of sucuk); often they are moderately chopped (majority of small-diameter dry sausages) and very occasionally finely chopped. They are cut in thin slices, their water content is under 35 percent, but normally less than 30 percent. Most varieties of dry sausages are subjected to cold smoking (12 to 18°C) but sometimes not; in some countries they are often heavily spiced with red pepper or garlic or sometimes heavily smoked and strongly salted. In principle, they are processed by long, continuous air-drying, sometimes after a

comparatively short period of smoking.

The formulation, degree of grinding, level of fermentation, smoking intensity, temperature of ageing and type and size of casing as well as other factors determine the properties of the final product. Dry sausages are stuffed in both natural and artificial casings of varying diameters. In the preparation of dry sausages natural casings are preferred because they adhere closely to the sausages as sausages shrink. Sausages stuffed in casings with a diameter exceeding 4.5 cm are often called “salami”; salamis are chiefly made from coarsely ground meat, predominantly of pork and are not smoked. The shelf life of dry sausages is excellent, which may be especially attributed to the high salt-to-moisture ratio. These sausages are normally kept without refrigeration.

Raw sausages, which are not submitted to the smoking process, are known as air-dried sausages. This variety of dry sausage is

characterized by a highly attractive appearance and by its yeasty-cheesy flavour. Air-dried sausages are marked with or without mould overlay.

The principle dry sausages are salami of different types produced in many countries followed by cervelats and many small-diameter dry sausages. Dry sausages may be hard, intended for slicing, and soft style sausages, which can be spread. An especially important fact in dry sausage manufacture is that the same raw materials, stuffed into different casings, give a quite different finished product. The wrapping of the twine on the sausage, contributing to the strength of the casing, is also of importance. Some large diameter sausages are corded with many loops and 3 to 5 longitudinal strands, while others have only circular twine.

Dry sausages are usually sold as new dry sausages (about 20 percent weight loss from original weight), moderately dry (about

30 percent of weight loss) and dry sausages (about 40 percent of weight loss).

OPERATIONS IN FERMENTED SAUSAGE PRODUCTION

Choice of raw materials.

The meat of adult, well-fed animals is preferred in raw sausage production. The use of chilled meat with a low pH is most suitable. For beef, the lowest pH of about 5.4–5.5 is obtained within a couple of days. Pork usually acidifies a little faster with final pH of 5.7–5.8. It is recommended to use meat that has been slightly frozen (-3° to -5°C) for one or two days prior to processing. The same holds true for fatty tissue. The use of beef is somewhat preferred for semidry sausages while pork seems to be more suitable for dry sausage manufacture.

All meats used in raw sausages need extra careful trimming of fat

and sinews; soft intermuscular fatty tissue in particular should be thoroughly removed.

Spices contribute mainly to the development of flavour in dry sausages but it has been shown that they also possess an inhibitory and stimulatory activity, thus influencing the growth of certain bacteria. Of the bacteria studied, *Lactobacillus plantarum* was found to be the species most frequently stimulated by different spices with respect to growth and to acid production.

Grinding, chopping and mixing.

Methods of grinding and chopping vary widely with the different types of semidry or dry sausages. In a general way it can be said that the finer the degree of grinding and chopping the more complete will be the extraction of protein while the spreading or slicing properties of the finished product will be improved. The same is true for bacterial contamination. Beef is normally

chopped first and then the pork components and other ingredients are added. Salt is added at the very end of chopping.



Fig. 24 RAW SAUSAGE PREPARATION IN THE CUTTER
*(Photo courtesy of Kraemer und Grebe, GmbH & Co KG, D-3560
Biedenkopf-Wallau, W. Germany)*





Fig. 25 FILLING AND LINKING SAUSAGES IN SMALL-SCALE PRODUCTION

The chopped meat mass should be well mixed with other ingredients and should be either immediately stuffed or placed in shallow pans and held under refrigeration to enable the curing process and stabilization of microflora. The meat mix in pans must not contain air pockets which are excluded by kneading; at the same time, the meat should be covered to eliminate its

contact with air.

Stuffing.

After remixing again in the mixer, the meat mix is packed in the stuffer as firmly as possible to exclude air pockets. Stuffing into casings should also be done firmly and carefully to exclude air. Air inside the casing will discolour the meat and reduce the shelf life of the sausage. After the sausage has been stuffed, the open end is tied (or clipped) and a loop is formed so the sausages can be suspended on rods. The air pockets under the casings are punctured wherever they are visible to eliminate air.

Raw sausages have historically been produced in natural casings. Many of them are identified by the casing used or by the manner in which string is tied around them. Casings, natural or artificial, should be prepared with great care. Sewn beef casings are also used for some large diameter semidry sausages.

Treatment prior to smoking.

The stuffed sausages are placed in a special place or room to enable the surface moisture to escape. The optimum temperature of this preliminary drying varies from 20 to 23°C and the relative air humidity should not exceed 75–80 percent. The sausages must neither dry too fast nor retain surface moisture and become slimy. Another alternative is to hang the sausages overnight in a chiller at 6–8°C. If the sausage casings are overdried, smoke will not penetrate.

Smoking.

Only hardwood sawdust smoke is applied. Uniform distribution of temperature and smoke throughout the smokehouse is essential. There is no standardized procedure for smoking different raw sausages. Sausages are smoked from several hours to several days or weeks according to the diameter of the product: small

diameter sausages, from 10 to 40 hours; medium diameter sausages, 15–45 hours; and large diameter sausages, several days and exceptionally 1–3 weeks.

In traditional smokehouse, uniform distribution of smoke throughout the smokehouse can be achieved by the appropriate distribution of the fire pits in different parts of the smokehouse. In a modern well-designed smokehouse, the smoke density and its distribution are maintained at the required level with equipment provided for controlling circulation, temperature and humidity. While liquid smoke solutions are commonly used in many meat products, the use of liquid smoke sausage manufacture is not really consistent with traditional practices.

The smoking of semidry sausages differs from that of dry sausages.

Semidry sausages are usually smoked at a higher temperature

(22–32°C or above) and a heavier smoke is usually applied. During smoking or prior to smoking of semidry sausages the fermentation process is usually accompanied either by chance contaminants or by added starter cultures. By chance contamination, successful products are not always produced.

Quite often semidry sausages are subjected to temperatures of 50–60°C in order to improve flavour and to inhibit bacterial development. To avoid excessive shrinkage, smoked sausages are removed from the smokehouse as and when they are properly smoked. Different diameter sausages need different smoking times.

The smoking temperatures required for different dry sausages vary from 12–22°C but never exceed 30–31°C. A temperature of 14°C is considered as optimum in dry sausage smoking. Some producers in Europe or the USA do not smoke their dry sausages at all but keep them for at least ten days to several months in a

room in which the desired air conditions are obtained by various combinations of temperature, relative humidity and air circulation. Some sausages are lightly smoked before drying.

Drying.

Drying or ageing is a key operation, especially in dry sausage production. The drying rate for dry sausages should be as low as possible. The most critical point in drying is to avoid the pronounced surface coagulation of proteins and the formation of sausage surface skin. If the sausages lose moisture too rapidly during the initial stages of the drying period, the surface becomes hardened and a crust or ring develops immediately adjacent to the casing. This hardened ring inhibits further transmission of moisture and the sausage has an excessively moist centre. Only a sufficiently wet and soft casing, a high relative humidity at the outset of the drying operation and the use of a lower relative humidity in the advanced stages of the

process will permit moisture to migrate from the interior of the sausage into the outer layer. Thus, the sausage should dry from the inside outwards. If the outer layers of the sausage become hard, the diffusion of water will be inhibited and the sausage tends to spoil. In conclusion, if the drying rate is adequately slow the sausage casing will enable gradual drying.



Fig. 26 SMOKING OF SAUSAGES IN MORNING AND EVENING HOURS IN TROPICAL CONDITIONS

At the start of the drying or the drying and smoking process, relative humidity can be as high as 98 percent. In the following 2–4 days the relative humidity must gradually but slowly be reduced. In that manner, the drying rate at the surface will be kept as low as possible. It is advisable to regulate the relative humidity according to the decrease in water-activity value of the product. Thus, the air relative humidity should be approximately 4 percent lower than the value of water activity of the product. For instance, when the water activity value of the product is 0.96, the optimum relative humidity of the smokehouse should be about 92 percent etc.

Too much humidity in the drying room favours the development of mould and sliming of products. Some producers do not object to a light white surface mould at the very beginning of the drying

process. When fully developed, the mould is brushed off or, in some cases, washed. It is believed that mould contributes to the specific flavour of some products.

Sausages, produced in tropical climates, should be thoroughly dried, and smoked more heavily than products in the moderate climatic regions.

Sausage drying rooms should be equipped with a fan, and with facilities for dehumidification and chilling or warming the air, if necessary, as well as humidity and temperature control instruments.

Traditional and modern methods of sausage fermentation.

In raw sausage manufacture, amongst the many factors involved, development of microflora and its effect on product quality plays a major part. The fermentation process in particular results in the

desired flavour characteristics and tang.

In the traditional production process, fermentation is accomplished by natural flora. In order to achieve safe fermentation of the raw sausage, it is of importance to give the microflora the proper growth conditions as well as the appropriate type of the meat. One of a number of methods offered for choice are procedures requiring extended incubation times. For instance, the raw sausage mixture, containing meats, curing salts and sugar, can be placed in 15–18 cm deep pans and kept for 2–4 days at 3–4°C. After remixing, the mix is stuffed into casings and the drying process continued at 12–15°C with or without simultaneous smoking. A number of alternative procedures are found in practice.

The inherent bacterial sausage microorganisms use various sugar substances as energy sources, whereby they produce acids and contribute to the flavour of the raw sausages. While

dextrose is degraded by almost all kinds of bacteria, lactose or starch products of higher molecularity are converted only by some of them. In the second case, the speed of acidification is delayed. Acidification, i.e. with a sufficiently low pH (below 5.2–5.3) is indispensable for adequate binding and colour development in the sausage. A pH value of 4.8 or below influences the taste, but does not contribute to better binding properties of the final product. However, this low pH gives fermented sausages excellent keeping qualities.

In general, addition of sugar varies from 0.3 to 2.0 percent. If dextrose or other easily degradable sugars are used, acidification is fast and the amount of sugar added should be somewhat lower. In opposition, corn syrup solid must be added at somewhat higher levels in order to compensate for its lower acidification properties.

A sufficient level of acidification can also be obtained by the

addition of glutamine or some other acids and particularly by the addition of glucono-delta-lactone (GDL). When GDL is used, acidification (release of gluconic acid) occurs at 21–23°C. At GDL levels under 0.5 percent, the curing agent should be nitrate, but at GDL levels higher than 0.5 percent nitrite is preferred since too high a rate of acidification does not permit the process of denitrification performed by microorganisms.

Traditional fermentation of dry sausages in the pre-1940 period was performed as mentioned above by the inherent lactic acid-producing microorganisms or by back-inoculating a portion of recently fermented meat into the freshly prepared batch.

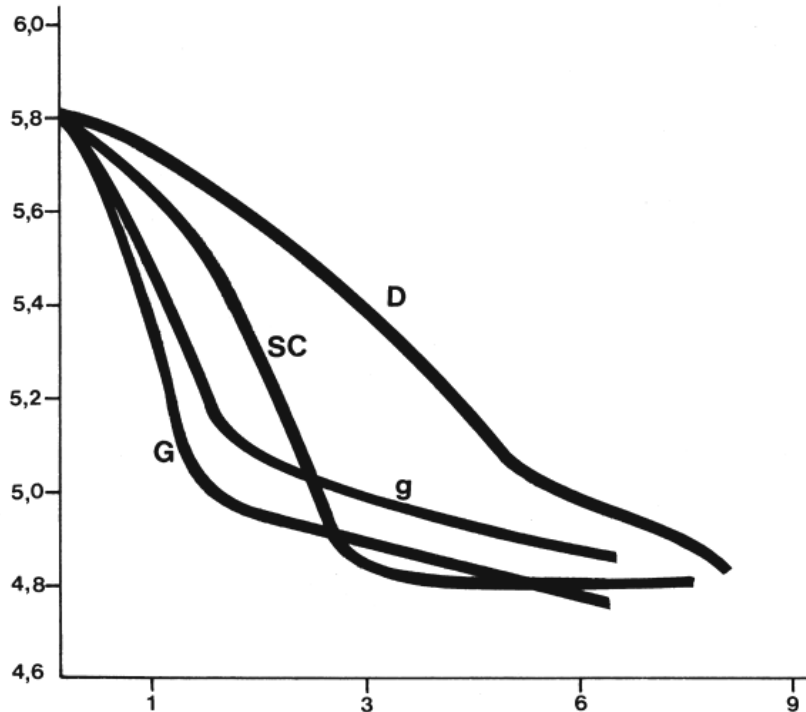


Fig. 27 RATE OF pH DECREASE IN FERMENTED SAUSAGES CONTAINING 0.5% DEXTROSE (D), 0.5% AND 0.8% GLUCONODELTALACTONE (g AND G) AND 0.5% STARTER

CULTURE PLUS 1% CORN SYRUP (SC)

However, this practice was associated with many doubts and uncertainties and to overcome them, the use of starter cultures was introduced in the early 1940s. The manufacture of fermented sausages changed essentially, particularly with the use of frozen concentrated starter cultures.

Bacterial starter cultures used in the production of dry sausages are lactic acid producing and belong mainly to the general *Lactobacillus*, *Pediococcus* and *Streptococcus*. Besides a few French (ferments lactiques) and American preparations of lactobacilli (Lactacell MC, etc.), and Spanish mixed-culture preparations, those mainly used on the European market are the micrococci and lactobacilli. As a matter of fact the market today is dominated by three types of products: starter cultures containing micrococci, starter cultures containing a mixture of micrococci and lactobacilli and starter cultures containing lactic

acid-producing cocci. The reason for applying these bacteria in the production of raw sausages is their ability to produce a consistent and controlled acidification able to inhibit growth of undesirable microorganisms and as an aid in obtaining the desired structure and colour of the final product.

Using starter cultures in current production practices, desired acidity can be achieved within 24 hours at a high (35–41°C) incubation temperature. This is in contrast to traditional manufacturing processes which utilized the natural flora of the meat as the source of lactic bacteria and required extended incubation times.

Storage.

If stored in a warm hanging room, raw sausages shrink excessively and they become firm; if left in too humid or too cool a room, they soon lose their colour.

Most producers favour handling raw sausages, especially in warm weather, in temperatures around 18–22°C. This is done to avoid condensation which gathers on smoked sausages transferred from a cold to a warm place, such as the ordinary meat shop. Such condensation favours rapidly forming moulds.

FERMENTED SAUSAGE FORMULATIONS

It is impossible to cover all the numerous types and potential variants of fermented sausages in this manual but it is possible to indicate some of the major products and suggest methods suitable for the manufacture of exclusive warm climate products. A point which is necessary to make clear is that every successful sausage manufacturer has to spend some time to adjust his sausage formulations to suit local requirements. Table 3 gives basic and supplementary spices used in semidry and dry sausage manufacture. The use of nonmeat ingredients in fermented sausage manufacture is discussed under the heading

“Nonmeat ingredients”.

1. SUMMER SAUSAGES

Summer sausages are usually coarse-ground fermented products. They are produced under conditions that promote microorganism proliferation which imparts flavour and the desired keeping quality. Starter cultures may be helpful in obtaining quality products.

FORMULATION

Basic ingredients for 100 kg

55 kg lean beef

25 kg pork bellies

20 kg pork fat

Characteristic seasoning formula per 1 kg

30.0 g nitrite salt for curing

0.5 g sodium nitrate

3.0 g black pepper, coarsely ground

1.2 g coriander

2.0 g mustard seed

0.4 g garlic, fresh

0.4 g allspice

5.5 g dextrose

2.5 g sucrose (some sausage makers prefer to have excess sugar present in final products which will produce the desired sweet flavour)

Casings

Pig casings: 35–45 mm in diameter

Processing and handling

The meat and fat are ground separately through a grinder plate having 5 mm holes. After thorough mixing, the sausage mixture is stuffed into casings. The sausages are tied into the desired length.

Further handling of sausages may differ. Sometimes they are fermented at 38°C and 95 percent relative humidity for 1–3 days. Fermented sausages may also be manufactured using a commercial lactic acid starter culture or 0.6–0.7 percent glucono-delta-lactone. The drying process is conducted until the desired degree of quality is reached.

2. AIR-DRIED SAUSAGES

This type of sausage is distinguished by high quality characteristics. The particularly attractive appearance as well as aroma and keeping quality are attributable to a low pH and low water activity. These sausages are predominantly pork products

and, if stuffed in wide casings, they are known as dry salamis.

The use of glucono-delta-lactone (0.3 to maximum 0.5 percent) can improve the texture and colour of the product and accelerate production but the quality of the finished product will be somewhat lower.

FORMULATIONS

Basic ingredients for 100 kg

- a. 20–35 kg beef, well trimmed, prefrozen
30–45 kg pork (derived from older animals), well trimmed of fat, prefrozen
20–30 kg backfat and pork belly**

- b. 20 kg beef, prefrozen at - 10°C
35 kg pork, prefrozen at - 5°C, well trimmed of fat
30 kg pork belly, prefrozen at - 5°C**

15 kg backfat, prefrozen at -5°C***Characteristic seasoning formulae per 1 kg***

- a. 30.0 g nitrite salt for curing**
 - 0.3 g potassium nitrate**
 - 2.0 g dextrose**
 - 4.0 g dry starch syrup**
 - 2.5 g ground white pepper**
 - 1.0 g white whole pepper**
 - 0.5 g coriander**

- b. 30.0 g nitrite salt for curing**
 - 0.3 g potassium nitrate**
 - 2.5 g dextrose**
 - 2.5 g dry starch syrup**
 - 5.0 g lactose**
 - 3.0 g white pepper, ground**

Casings

Corresponding diameters of artificial or natural casing

Processing and handling

The beef is chopped in the cutter to approximately 2–3 mm grain size and at the end of chopping all seasoning ingredients except salt are added and homogenized. Pork components are placed at a low cutter knife speed and coarsely chopped. Kitchen salt must be added at the very end of chopping.

The stuffed and tied casings are kept at 20–24°C with a high relative humidity (92–94 percent) for 24 hours. During the next 24 hours the relative humidity is reduced to 90 percent. In the course of the following 3–4 days, the temperature is gradually decreased to approximately 14–16°C as is the relative humidity. The rest of the ageing process is carried out at 14–15°C and 76–

78 percent relative humidity.

The uncontrolled growth of “wild mould” should be completely stopped for hygienic reasons. Should a uniform white surface coat of mould be desired, immersion inoculation with mould starter cultures must immediately follow stuffing.



Fig. 28 ALL-BEEF AIR-DRIED SAUSAGES IN BEEF CASINGS

PRODUCED IN HOT CLIMATE CONDITIONS

3. PEPPERONI

The name of this type of sausage is derived from the word “pepper”, indicating that pepper is used in its spicing. Pepperoni are often produced as an air-dried product. They can also be produced either as all-pork or all-beef products.

FORMULATION

Basic ingredients for 100 kg

50 kg pork trimmings

30 kg beef chucks, hearts, cheeks

20 kg pork jowl

Additional (nonmeat) ingredients

Addition of nonmeat proteins, such as whey or soy products to pepperoni mixture is sometimes practised.

Characteristic seasoning formulae per 1 kg

- a. 28.0 g nitrite salt for curing**
 - 0.5 g sodium or potassium nitrate**
 - 0.5 g chili**
 - 2.0 g allspice**
 - 1.5 g fenugreek**
 - 3.0 g ground pepper**
 - 4.5 g red pepper**
 - 1.5 g anise**
 - 10.0 g sugar**
 - 0.3 g peeled garlic**
 - 2.5 g dextrose**

- b. 30.0 g nitrite salt for curing**

1.2 g monosodium glutamate

4.0 g pepper

2.0 g red pepper

0.2 g chili

3.5 g dextrose

0.2 g garlic

Casings

Pig rounds: 28–32 and 35–44 mm in diameter

Processing and handling

Pork and beef are passed first through a 10–12 mm plate and then run through a 3 mm plate. The mixing and seasoning of meat is performed in a mixer for at least 5 minutes. The meat mixture may be then either cured in pans, 15 cm deep, for two days at a temperature of 2°C or immediately stuffed. After curing,

the cured mass is remixed and stuffed into casings without delay and linked in pieces of 24–25 cm. The linked sausages are dried or smoked and dried. Drying is carried out according to consumer taste.

If the mixture is not cured in pans but stuffed directly into casings, the sausages are held for about 10 days at 3°C prior to placing them in a green room at 22–24°C with a relative humidity of 80 percent for 48 hours. Smoking is performed at 32–34°C for 2–3 days. The sausages are further dried at 14°C.

An alternative method, especially if starter culture is added, is to ferment stuffed pepperoni mixture for 24 hours at 35°C and dry it at 12–14°C for 4–5 weeks or until desired firmness is obtained.

4. PORK AND BEEF CHORIZOS

Chorizos are a strongly hot spiced type of raw sausage, which

can be sold and used as fresh (like merguez), semidry or dry sausages. Beef and fat, such as beef chucks, brisket fat and trimmed flank may be used in making an all-beef sausage variant.

FORMULATION

Basic ingredients for 100 kg

33 kg lean pork or lean beef

33 kg pork neck or beef flank

34 kg fat pork (jowl, belly, fat trimmings) or beef trimmings

Characteristic seasoning formula per 1 kg

28.0 g nitrite salt for curing

0.4 g potassium nitrate

0.8 g sugar

1.0 g garlic, fresh

2.0 g red pepper

1.5 g chili

0.5 g glucono-delta-lactone (optional)

Casings

Narrow and wide pig or sheep casings (28–38 mm)

Processing and handling

The pork components are run through the 6–9 mm plate. If beef is used, it is ground more finely (3–4 mm plate). During mixing, curing salts and sugar are added and the mixture cured either in a shallow pan at 4°C or in casings after stuffing. Sausages are divided into lengths of 8–10 cm.

After several smoking days (cold smoking at 14°C), the sausages are held at the same temperature until the desired texture is obtained.

An addition of 0.4 percent glucono-delta-lactone (if potassium nitrate has not been added in the mixture) will considerably accelerate the formation of desirable texture and contribute to a better keeping quality of the product (see “Nonmeat ingredients”).

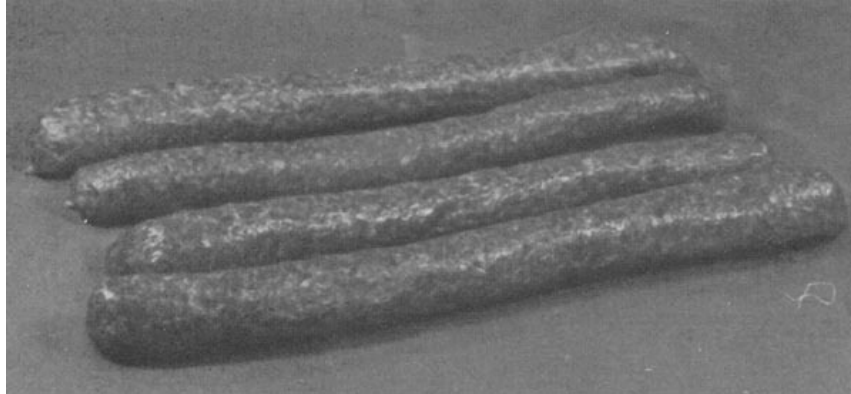


Fig. 29 A SEMIDRY ALL-BEEF SAUSAGE PRODUCED WITH AN ADDITION OF 0.4% GLUCONO-DELTA-LACTONE, USING FORMULATION GIVEN IN THE INSTRUCTION FOR “PORK AND BEEF CHORIZOS”

5. BEEF SALAMIS

There are several varieties of beef salamis, depending chiefly upon the length of the curing preblended sausage mixture, degree of fermentation, diameter of casings etc.

The acceleration of beef salami manufacture may be achieved by adding glucono-delta-lactone or 0.5 percent of a starter culture in the mixture before stuffing.

FORMULATION

Basic ingredients for 100 kg

75 kg beef chucks or other beef

25 kg beef brisket fat

Characteristic seasoning formula per 1 kg

25.0 g nitrite salt for curing

0.4 g potassium nitrate

0.5 g fresh garlic

2.5 g ground white pepper

2.0 g dextrose

1.0 g red pepper

0.2 g ginger

(lactic acid starter cultures may be added)

Casings

Beef middles or weasands

Processing and handling

The beef is run through a 4 mm plate of the grinder and the brisket fat may be diced. After mixing with other ingredients, the meat mass is placed in 15 cm deep pans for curing at 4°C for 15–

48 hours. The mass is then remixed and stuffed into casings. Stuffing and tying must be very firm. The smoking is performed at gradually increasing temperatures, sometimes to 60°C or even more to stop the fermentation process. If a fully fermented product is preferred, the sausages should be hung for 3–5 days at 18–22°C, smoked in cold smoke for 2–4 days and dried according to demand. After smoking, the salami may be rinsed with water and then chilled.

To avoid the growth of mould, the sausages after removal from the smokehouse can be rinsed in hot water saturated with salt.

6. TURKISH AND ORIENTAL STYLE RAW BEEF SAUSAGES

In traditional Near East meat processing, several groups of sausages can be found but beef sausages or “sucuk” are doubtlessly more typical and frequent. Sucuks are popular Turkish national products but they are manufactured throughout

the Near East by numerous local sucuk markers. This type of product substantially differs from its European counterparts. Sucuks are exclusively beef products but occasionally buffalo meat and, more rarely, mutton are used.

Sucuks are sausages of roughly comminuted meat, mixed with fat and other ingredients, stuffed into sheep or beef casings and exposed to smoking and/or drying, including sometimes sun-drying. They are often annular shaped.

There are at least several types of sucuks which can be classified according to proportions of fat and lean, diameter of casing used, degree of drying etc. Sucuk production varies much depending upon the season.

FORMULATIONS

Basic ingredients for 100 kg

- a. 80 kg beef
20 kg beef or mutton fat**

- b. 60 kg beef
30 kg mutton
10 kg fat**

Characteristic seasoning formula per 1 kg

- 25.0 g salt or nitrite salt plus 0.5 g potassium nitrate**
- 2.0 g black pepper**
- 2.0 g red pepper**
- 1.5 g garlic, fresh**
- 1.5 g cumin**
- 0.3 g cinnamon**
- 0.4 g ginger**
- 0.2 g cloves**
- 2.0 g sucrose**

Casings

Animal casings, mostly beef and sheep, 24–26 mm or more in diameter

Processing and handling

Prerigor meats are sometimes used in sucuk manufacturing. Meat grinding is very coarse (10 mm grinder plate is commonly used). All ingredients are thoroughly mixed together.

Casings for sucuk stuffing should be flushed inside with water just before use. Salted casings are washed free from salt before use and any casing that is left over should be resalted. Air-dried beef casings (air drying is the common method of beef casing preservation) must be free of any remnants of adhering fat. Artificial casings are also occasionally utilized.

The meat mass is sometimes chilled overnight and then firmly

stuffed. The stuffed sucuks are often pressed under boards by means of weight.

The sausages can be smoked several days or several weeks. In fact, the drying process lasts 2–3 weeks or more, depending on casing size. Air circulation is sometimes so high that sausages, particularly if the casings contain remnants of fat, very often acquire a slightly rancid tallow flavour. Intensive fermentation, which occurs rapidly during the first days of drying, nearly stops at the end of the process. For more details on processing and sucuk handling, see the instructions for “Pork and beef chorizos”.

The addition of 0.4 percent of glucono-delta-lactone in the sucuk mixture can considerably reduce production time and improve the keeping quality of the finished product.

The usually accepted quality requirements for European semidry

or dry sausages (flavour, colour) are often neglected by sucuk consumers. The most popular sucuk flavour is a specifically balanced mixture of fermentation products, added spices and components of fat and meat degradation. Very often the strongly accentuated garlic flavour and more or less fermented and, to some extent, rancid sucuk taste may be unpleasant to unaccustomed people.

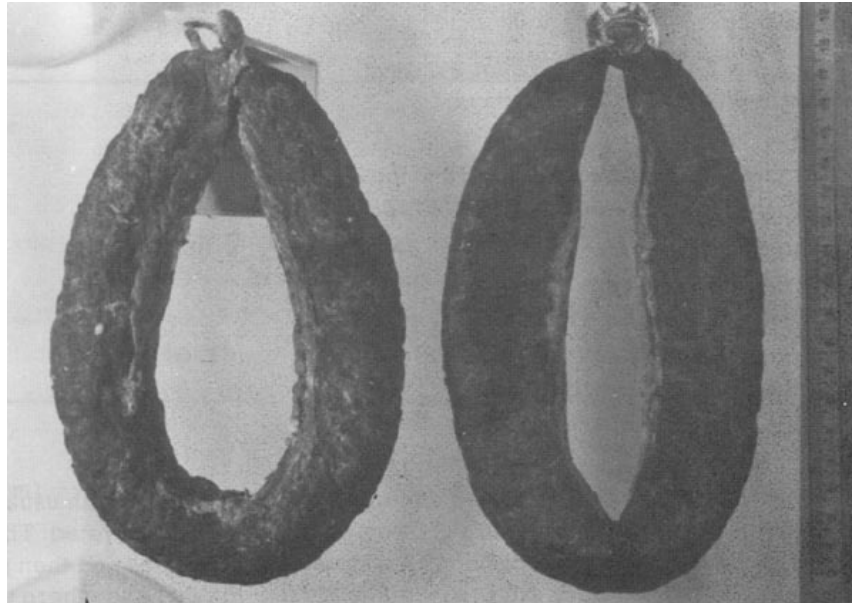


Fig. 30 BEEF RING-SAUSAGES OR SUCUKS ARE USUALLY STUFFED IN BEEF CASINGS WHICH MUST BE FREE OF ANY REMAINDER OF ADHERING FAT. ON THE CONTRARY, THE AIR-DRIED SAUSAGE MAY BECOME RANCID AND HAVE A POOR APPEARANCE

(Photo courtesy of Dr M. Marinkov)

7. LANDJAEGERS

“Landjaegers” or hunter's sausages are the flat dry sausages, made by stuffing a mixture of beef, pork and seasonings into a medium diameter casing and cutting the stuffed casings in desired lengths. The characteristic operation is pressing, usually in wooden moulds, to flatten the sausage. A possible alternative in the production of these sausages for tropical regions is to use all-beef ingredients.

FORMULATIONS

Basic ingredients for 100 kg

- a. 35 kg beef (may be held at - 10°C for 2–3 days)
65 kg pork bellies (- 10°C for 2–3 days)**

- b. 70 kg beef
30 kg pork backfat (may be held at - 10°C for 2–3 days)**

c. all-beef landjaegers**75–80 kg beef****15–25 kg beef fat*****Casings*****Pig or sheep casings, 26–34 mm in diameter*****Processing and handling***

The beef is coarsely ground or directly chopped and then worked to a mass with usual additions (salt and seasoning). At the very end of chopping, the pork components are incorporated. The mix is stuffed into pig or sheep casings, cutting the stuffed casings off in about 30 cm lengths and then placing the sausages in wooden moulds. The sausages are pressed into the moulds by hand where they take on their flat shape and each link is separated into two identical sausages connected together by a

section of empty casing. Depending upon the force of pressure the sausages are produced in different thicknesses.

The landjaegers are allowed to remain in the press for 1–2 days at about 20–24°C or for about 2–3 days at approximately 18–20°C, giving sufficient time for biochemical and microbiological processes and for obtaining the required flat shape. The shaped sausages are then removed from the moulds, placed on smoke rods and hung for 3–4 days in a cold room (16–20°C) for surface drying and further “ripening”. The sausages are then given a cold hardwood smoke overnight or a little longer.

From the smokehouse, the sausages are taken again to the drying room for half a day and then stored or packed.

Freshly stuffed sausages are 6 to 7 pairs to a kilo; and the finished product about 9 to 10 pairs to a kilo. Shelf life is at least 60 days.

8. BASIC FORMULATIONS FOR SELECTED LARGE AND SMALL DIAMETER FERMENTED SAUSAGES

The following is a list of basic formulations for selected large- and small-diameter fermented sausages which are known as a traditional dry product (Table 7).

Table 7 BASIC FORMULATIONS FOR SOME FERMENTED SAUSAGES

Sausage	Beef %	Pork %	Pork backfat %	Spices¹
<i>Large diameter (salami)</i>				
German type		65–75	25–35	coriander, garlic
Italian type	30	45	25	ginger, garlic
Hungarian type		70	30	red pepper, nutmeg,

Polish type	10– 15	55– 60	25–30	cardamom, garlic marjoram
<i>Small diameter</i>				
salametti (28/32 mm)	30	40	30	
garlic sausage (24/28 mm)	50	20	30	red pepper (hot), rosemary, garlic
beef garlic sausage (24/28 mm)	80		20 (beef fat)	fenugreek, red pepper, ginger, garlic

1 — 1.0 g/kg monosodium glutamate may be added per 1 kg of product — addition of 1.5–5.0 g pepper is practised per 1 kg of product



SMOKED PRECOOKED SAUSAGE PRODUCTION

Smoked precooked sausages comprise a heterogeneous class of sausages. They are smoked and/or air heated, often cured, but not fermented. Due to their formulation and the necessity, in general, of additional cooking before serving, smoked air-cooked sausages are usually classified together with fresh sausages but differ from the latter by considerably longer shelf life.

Smoking is normally performed immediately after stuffing. The sausages are generally precooked in a smokehouse in two phases: (a) steaming for 3–5 or more minutes to an internal temperature slightly above 50°C and (b) dry heating to an internal

temperature of 64–65°C. Following this procedure quick chilling is advisable. The chilling operation contributes to the texture, appearance and overall consumer acceptability of the final product.

The shelf life of sausages depends to a large extent on the methods of processing that are employed. A long and slow process and any delay in operations lead to the development of extensive microflora. On the contrary, if the bacterial count of raw materials is low and kept to a moderate number during processing subsequent smoking and precooking may inhibit or kill most of the bacteria. When such a product is held at lower temperatures and lower relative humidity, a progressively smaller proportion of the bacterial contaminants is able to grow and their growth occurs at a lower rate. This is the reason why fresh sausages, produced in strict accordance with hygienic and technological requirements and then slightly smoked and only partly cooked, may be stored for a prolonged period even in

tropical conditions.

The contents of salt and fat and the addition of rusk and soy protein reduce to a certain extent water activity of the product, contributing to its shelf life. The microbial numbers decrease as the level of fat increases and increase with reduced meat particle size.

The precooked sausages are usually recooked by consumers from the chilled or thawed state by grilling for 3–5 minutes. If in a frozen state, they should be cooked for 8–10 minutes.

In the class of smoked precooked sausages a particularly special position belongs to the group of Chinese sausages.

1. SMOKED PORK SAUSAGES

These sausages should not be too fat. An excessive amount of fat results in considerable shrinkage during smoking. Typical

smoked pork sausages are somewhat underspiced in order not to interfere with the smoke flavour. Smoked pork sausages are mostly a cured product.

FORMULATION

Basic ingredients for 100 kg

75 kg lean pork

25 kg fat trimmings (pork) or pork jowls

Characteristic seasoning formula per 1 kg

20.0 g nitrite salt for curing

1.5 g pepper

1.0 g mace

1.5 g sage

1.0 g sugar

0.2 g monosodium glutamate

Casings

Pig rounds: medium (35–38 mm), regular medium (32–35 mm) and rarely narrow medium (28–32 mm)

Processing and handling

Lean meat and fat trimmings are coarsely ground. After grinding, the batch is mixed for approximately 2 minutes in a mixer to distribute the added fat and seasoning and then stuffed into casings.

Smoking can be performed either immediately after stuffing or the links can be kept overnight in a chiller at 0–4°C. A variety of smoking procedures exists: hot smoking at 65°C for 25 minutes, cold smoking for about 10–12 hours with dense smoke at temperatures not exceeding 20°C etc.

Smoked pork sausages are kept at temperatures close to

**freezing point but it is not recommended to freeze them.
Refrigeration shelf life of smoked pork sausages is not more than
3–4 days.**

2. PRECOOKED PORK SAUSAGES

Precooked pork sausages are known in many varieties.

FORMULATION

Basic ingredients for 100 kg

100 kg pork trimmings

or

80 kg pork trimmings

10 kg beef trimmings

10 kg pork cheeks

Characteristic seasoning formula per 1 kg

18.0 g nitrite salt for curing

2.5 g white pepper

2.5 g fenugreek

2.5 g red pepper

1.2 g coriander

0.3 g chilli

Casings

21–22 mm animal or artificial edible casings

Processing and handling

The chilled trimmings are ground through a plate, having holes of 5–8 mm in diameter. The salt and spices are sprinkled into the ground meat while mixing. The sausages are stuffed into 22 mm sheep or collagen casings or into 21–22 mm cellulose casings. Linking is performed at 10 cm intervals. The smoking schedule is

as follows: 2 hours at 38°C with dampers closed, then 1 hour at 50°C with dampers partially open and finally at 78°C or until a 65°C internal temperature is reached.

If skinless precooked sausages are wanted, steam cooking at 75°C for 3–4 minutes should be applied and after cold showering for 3 minutes, the sausages are peeled.

3. SMOKED BEEF SAUSAGES

The formulation of these sausages differs from fresh grill beef sausages by having a considerably higher fat content and a fairly small diameter.

FORMULATION

Basic ingredients for 100 kg

40 kg lean beef

20 kg mutton

20 kg beef trimmings

20 kg zebu boss or beef brisket fat or mutton tail fat

Characteristic seasoning formula per 1 kg

22.0 g nitrite salt for curing

0.5 g chili

5.0 g red pepper

0.3 g garlic

0.2 g cinnamon

1.0 g ground pepper

0.5 g sugar

Casings

Goat or sheep casings: narrow (under 18 mm), and exceptionally narrow medium (18–20 mm)

Processing and handling

Beef meats are run through the grinder with a fine plate (2–4 mm), mutton through a 6 mm plate and fat through a coarse plate. The ground meats are thoroughly mixed with the other ingredients, adding a small quantity of water or milk, if necessary, and then filled into narrow sheep or goat casings. Air pockets within the sausages produce unsatisfactory results, causing uneven cooling, nonuniform weight and possible curving of the product.

The sausages are further processed by smoking and air heating, normally for 3–5 days or longer as may be required at suitable temperatures, preferably at 16–19°C with sufficient circulation. Higher temperatures can be applied, provided narrow casings are used. If they are sufficiently smoked and dried, the sausages have a good keeping quality.

4. PRECOOKED BEEF SAUSAGES

Fresh beef sausages which have been precooked have been introduced in some countries. These sausages enjoy the advantage of a longer refrigerated life.

FORMULATION

Basic ingredients for 100 kg

80 kg beef trimmings

10 kg beef brisket or flank

10 kg beef fat

Characteristic seasoning formula per 1 kg

18.0 g nitrite salt for curing

2.5 g black pepper

3.5 g red pepper

0.3 g chilli

0.5 g garlic

0.6 g corn syrup

Casings

22 mm sheep or goat casings; 21–22 mm collagen casings

Processing and handling

Processing operations are performed as described in the instructions for precooked pork sausages.

5. SMOKED PRECOOKED BEEF SAUSAGES

Smoked air-cooked beef sausages are characterized by a longer shelf life. Apart from smoking and slight cooking, the shelf life of these sausages is increased by a higher level of salt and by an elevated fat content.

To delay or prevent oxidative reactions of fat and improve the product storage life, a combination of spices, including rosemary, sage and whole mustard seed is incorporated in the formulation. The ground mustard seed may be added directly into the cutter. It should be pointed out that only by carefully controlling the degree of rehydration is it possible to avoid the development of an excessive mustard flavour in the final sausage product.

FORMULATION

Basic ingredients for 100 kg

55 kg beef (if possible prerigor beef)

25 kg mutton fat

20 kg beef flank

Characteristic seasoning formula per 1 kg

22.0 g nitrite salt for curing

2.0 g red pepper

0.3 g garlic

0.3 g cardamom

5.0 g sage

1.5 g celery

0.5 g rosemary

12.0 g ground dehydrated mustard seed

4.0 g corn syrup

10.0 g soy protein concentrate (textured)

Casings

Goat and sheep narrow casings: 16 mm in diameter

Processing and handling

After grinding, the pork is sprinkled with seasoning and mixed

thoroughly to distribute all components evenly. Other operations are as described in the instructions for smoked beef sausages. The only exception is the use of a higher smoking temperature or, if excessive smoking is undesirable, higher drying temperatures. The whole process may take from 4 to 5 days.

6. CHINESE SAUSAGES

Chinese sausages, the most popular meat products in China, are basically made from pork. The Chinese name for sausages is “Lap Chong” of which the nearest translation would be “winter stuffed intestine” or “waxed intestine”, because “chong” not only means “intestine” but also “sausage”.

Chinese sausages differ according to their formulations, size and methods of processing. Chinese sausages differ essentially from other sausages. Their formulations and manufacture are unique, based on long tradition and their kitchen preparation is also

rather particular. Sausages are used primarily in China as a flavouring agent and as protein fortification for a number of rice, noodle or other dishes in which they are added in quite small amounts.

An important part of Chinese sausages flavour consists of monosodium glutamate, soy sauce and sugar that are added to the sausages in exceptionally high levels. The addition of selected Chinese wines is common for certain quality products. The most popular spice is cinnamon (*Cassia*) since Chinese sausage producers believe that it acts as a preservative.

Sausages are eaten all the year round in China but consumption is greater during festive seasons, especially during the Chinese New Year.

According to the formulation, Chinese sausages may be divided into meat sausages (Yuen Chong) and liver sausages (Goin

Chong). A special class of sausages are chicken liver sausages containing chicken livers or chicken livers combined with selected young pork livers. Processing methods and seasoning formulae are similar in both main groups of Chinese sausages.

FORMULATIONS

Basic ingredients for 100 kg

meat sausages

60–74 kg lean pork or lean pork trimmings
25–40 kg pork backfat

Liver sausages

25–50 kg lean pork
30–40 kg pork backfat
20–40 kg pork livers

Additional ingredients per 100 kg**10–18 kg water****1.5 kg Chinese wine (“Mei Kwei Lo” etc.)*****Characteristic seasoning formula per 1 kg*****20.0 g nitrite salt for curing****10–50 g sugar****1–3 g monosodium glutamate****15–20 g soy sauce****0.6–1.2 g cinnamon****(ginger and other spices may be blended in limited quantities)*****Casings*****Pig rounds narrow medium (28–32 mm) and narrow (diameter less than 28 mm)**

Processing and handing

Operations involved in the production of Chinese sausages usually include running of deboned meat and fat through a grinder or reducing the meat by knife in small pieces or dices, adding seasoning, and mixing, stuffing into casings, linking, heating or hot smoking, chilling, “sweating” and packaging. Throughout this chain of operations, the meat mixture is gradually transformed into the final product or sausages

***Grinding and mixing.* The normal Chinese way, still commonly applied, is a time-consuming operation of cutting lean pork and fat by hand into small cubes. Using semi-industrial methods, pork is broken down through a 16–18 mm grinder plate and the fat diced by means of a semi-automatic fat cube cutter in approximately 0.7 cm particles. The fat cubes are then scalded with hot water, drained and coated with an “antioxidant-vegetable fat” mixture; the fat should be allowed to stand for 3**

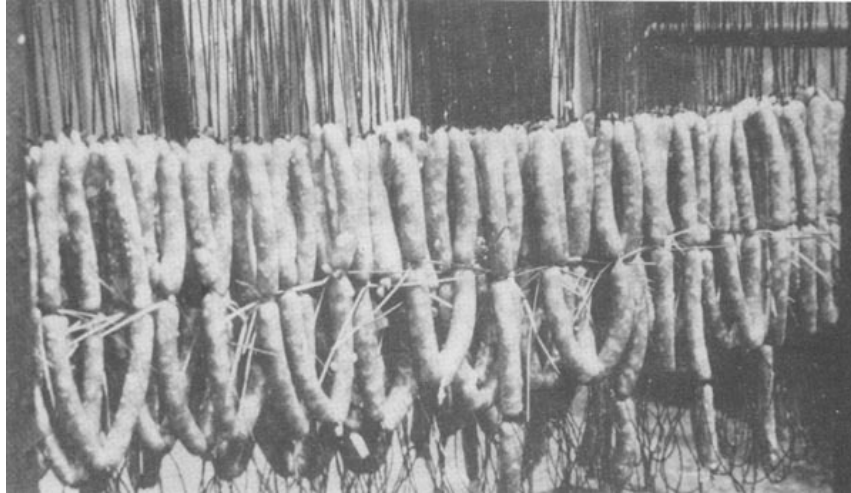
hours for the antioxidant to penetrate into the cubes. Such a procedure enhances the shelf life of the product against fat rancidity and off-flavour. With the industrial method, meat and fat can be placed in a cutter along with the other ingredients and the work is completed in 2 or 3 minutes.

If nitrite salt for curing is added, the mix should be allowed to stand for 3 hours at 5–8°C in a pan in the chillroom. At the end of the reaction period, the diced fat is added and mixed with the seasoning and water. An important amount of water is deliberately added to the meat mixture to facilitate mixing and stuffing operations. The mixing operation is performed either by hand or in a mixer.

***Stuffing.* Typical Chinese-style sausages are usually stuffed into dried pig or sheep narrow casings, 18–24 mm in diameter. Stuffing is usually done manually and by means of very simple fillers, resembling ordinary funnels. Filling should not be too**

compact or too loose as this would ultimately affect the size of the finished product. The sausages are linked with pieces of straw (traditional Chinese method) or both ends are tied into 10 or 15 cm links with light twine. The filled sausages are further washed in water to remove small pieces of adhering meat and left to dry in a smoke chamber.

Immediately after stuffing the sausages are densely perforated on all sides for the escape of entrapped air and also water vapour during the next stage of smoking.



**Fig. 31 CHINESE SAUSAGES LINKED WITH PIECES OF STRAW
PRIOR TO SMOKING**

Drying and smoking. This is the most important operation in Chinese sausage manufacture. The most suitable type of drying room or smokehouse for Chinese-style sausages is usually an especially designed brick-built unit with very simple installations. In its more sophisticated form the unit can be equipped with two

or three doors, one or more dampers and be very different in size and shape. Small manufacturers successfully use a small gas oven for drying their sausages.

In drying Chinese sausages, the main aim is a constant and uniform supply of heat (and smoke, if desired) to produce a uniformly dry product. Maintenance of good air circulation is essential and the sausages must be hung in a well-spaced manner on racks in the smokehouse. At the beginning of drying and smoking, the relative air humidity is quite high, but it is gradually lowered and the degree of sausage dehydration is accelerated. Drying is done at 48–50°C for 72 hours.

Some manufacturers prefer a combination of smoking and drying, and this is done in two phases: at 50°C for 48 hours with or without added smoke (dehydration through added water) and at 60–65°C for an additional 15–24 hours, usually without added smoke (dehydration of the original meat water). As hardening of

casings and surface microbial growth must be avoided, the successful execution of the drying and smoking process requires special skill and long experience.

Generally, weight losses may be estimated at about 40 percent for meat sausages and 45 to 48 percent for liver sausages. Irrespective of the initial moisture content in the formulation. Chinese sausages are normally dried to reach a low moisture percentage.



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Fig. 32 CHINESE SAUSAGES, KUALA LUMPUR MARKET.

The differences in grades, reflecting qualities are marked by the colour of the sausage hanging strings.

Chilling and “sweating” process. The sausages are removed from the smokehouse and placed in a well-ventilated room for chilling. They are then either stored in bins or in cardboard cartons to undergo the “sweating” process, i.e. for one or two days, the moisture in the sausages becomes evenly distributed causing softening of the outer parts from the sausage interior. The product is then ready for packaging.

EATING AND KEEPING QUALITY CHARACTERISTICS OF CHINESE SAUSAGES

Chinese sausages are dry, smoked, strongly flavoured products. Their flavour is a combination of heavy seasoning, in which soy

sauce has a dominant role, smoke components and products of thermal degradation of the meat itself. There is no doubt that the simultaneous effects of both smoke and heat have a marked impact on all organoleptic and structural properties of the meat. High temperature treatment also initiates oxidative changes of fat and other constituents which are continued throughout storage.

The surface colour is dark reddish-brown in Chinese meat sausages and dark brown or brown-black in liver sausages. Fat colour is yellowish-grey, rarely yellowish-white. The sausage surface is normally shrivelled due to quick drying. The casings adhere well to the sausage content.

Moisture content is lowest at 7–8 percent and highest at over 20 percent. At the same time, the minimum fat content is about 40 percent and the maximum about 70 percent. Sugar content ranges from 9–20 percent, while the amounts of protein and salt vary from about 9 to 24 percent and 3 to 5 percent, respectively.

The excellent keeping quality of Chinese-style products is influenced both by appropriate formulation and by processing methods. High fat, salt, sugar and protein contents and an amount of water reduced by drying to a very low level cause an important decrease in water activity value. A sausage product containing 40 percent of fat, 3 percent of salt and less than 20 percent of water has a final water activity value under 0.85 and the multiplication of bacteria and yeasts is basically blocked. Preserving compounds, resulting from smoking and heat degradation of the meat itself, together with the soy sauce components and the effect of cinnamon which is known for its antimicrobial activity, are further factors contributing to the keeping life of Chinese sausages.

Most producers of Chinese sausages have their own quality grades. The differences in grades, reflecting quality and proportion of ingredients used, are mostly distinguished by the colour of the sausage hanging string.



PRODUCTION OF EMULSION-TYPE SAUSAGES

The procedures used in the production of frankfurters are typical for all fine cut emulsion-type sausages. The term “meat emulsion” has been used as a general term to describe frankfurter-type sausages. As the mixture of protein, fat and water, is not a true emulsion the term meat “batter” instead of meat “emulsion” might be better.

Emulsion-type sausages originated in Europe, where they were mainly produced from hot (prerigor) meat. Emulsion-type sausages may be subdivided into small diameter and large

diameter sausages. Frankfurters and wieners are examples of small diameter emulsion-type sausages. Originally, wieners were stuffed in sheep casings and frankfurters in pig casings. Bologna or mortadella are similar products but filled into large casings (beef middles, bungs or rounds, or synthetic casings).

Emulsion-type sausages are basically made from a mixture of finely chopped meat, fatty tissue and water or ice. They are usually smoked. The formulation for this type of sausage not only contains meats of high water binding properties but also includes meats characterized by intermediate binding properties. In the lower grade type sausage, filler meats such as weasands or giblets, or other meats of inferior binding capacity (tongues, snouts, lips etc.), may be added but it is generally accepted that these components should not exceed 15–20 percent of sausage formulation. Emulsion-type sausages do not normally contain typical variety meats.

Meat formulae of these products vary widely and surprising differences are often noticed. The main constituents are beef and pork. Wieners traditionally contain some veal. All beef products are made with a mixture of beef and veal, or only of beef. Non-fat milk powder, cereals, starch and other nonmeat ingredients may also be used to the extent regulated by local or state standards.

Generally speaking, emulsion-type sausages are technologically mainly dependent upon the state of beef proteins and their water binding and emulsifying properties. Although they often contain pork, water binding and emulsifying properties of this type of meat are utilized to a lower extent due to its usual high fat content.

Emulsion-type sausages are ready-to-serve products. Small diameter sausages are usually eaten after immersion in hot water for several minutes; only rarely, they are grilled prior to consumption.

OPERATIONS IN EMULSION-TYPE SAUSAGE PRODUCTION

Choice of meat.

The meat ingredients must be absolutely fresh and derived from veterinary-inspected animals. Both frozen or chilled beef is used successfully. The lean meat should be well trimmed to a level of less than 10 percent of nontrimmable fat and connective tissue, the trimmed lean meat thus being practically free from sinews and gristle and entirely free from ligament, bone and cartilage particles.

The selection of meat should be such that most meat ingredients are of a good water binding capacity. Except for the binder and filler meats mentioned earlier, pork and veal rinds are also employed by some sausage makers in formulating low cost frankfurter products. Rinds provide an economical source of protein and may be employed in varying proportions depending

on the legally permitted amount for that product. Raw rinds may be used but because of their high bacterial count they are normally heat processed in order to arrive at a count suitable for inclusion into comminuted products. The fresh rinds have to be stored under refrigeration.

Precuring.

Precuring of meat in pieces is no longer practised by meat processors. This operation is replaced today by adding curing salts at the time of chopping.

Grinding.

The grinding of meat and fat ingredients has largely been practised for many years and is still done today mainly by small processors, particularly in the manufacture of speciality products.

The fist-size chunks of lean meats are first grinded by running them through a 3–6 mm grinder plate while fat trimmings or fatty tissues are reduced through a 6–9 mm grinder plate. The tripe and the filler meats are preferably grinded twice: first, through a 3–4 mm and then through a finer grinder plate. Grinding through a coarser plate increases the capacity of the machine and heats the meat less. Particularly for bull meat, grinding through a finer plate is considered to give a product with better binding and emulsifying properties.

The curing salts are then added and the batch is mixed in a mechanical mixer to ensure that the ingredients are well dispersed. The curing process may take place either overnight in a chiller at 1–4°C (this practice is being increasingly abandoned) or after final chopping in the cutter with other ingredients and stuffing, i.e. prior to or during smoking.

In many emulsion-type sausage procedures, a precomminution in

the grinder is followed by chopping because it contributes to a better and more uniform size reduction in the cutter. In many cases comminution is not too finely done.

Chopping.

The grinding of meat has by large been replaced by cutter chopping which renders a fine meat-fat mixture, usually known as an “emulsion”. However, in small-scale sausage manufacture, the meat is still often previously ground and then transferred to the cutter for chopping. During the chopping process the meat is cut to a very fine particle size which encourages protein extraction. Proteins have the function of binding the water surrounding fat droplets and keeping them dispersed.

Preparation of sausage emulsion is basically in two phases. First, the lean meat, either previously ground or not, is placed in the cutter and chopped. This is done by the simultaneous addition of

all the curing salts (kitchen salt, nitrite), phosphate and/or citrate for the total batch and one-third of the total amount of finely crushed ice or water. Increased salt concentration in the water phase of the mixture will result in a greater extraction of the meat protein and is of paramount importance in forming a stable emulsion. The extraction of protein is most effective when the meat is near freezing point but the emulsification process is adversely affected by low temperature. Since protein extraction is increased with the time of chopping, the lean meat should be chopped for a sufficient period, normally not less than 6–8 minutes. After this time, fat trimmings, pork jowls and other fat meats, then sweeteners, spices and the remaining two-thirds of the total water are added. Chopping is then continued until the batch is thoroughly chopped or the temperature of the meat mass reaches not more than 18°C (second phase). In the course of this time, all water is taken up by the disintegrated and homogenized meats. If sodium ascorbate is used, it is also added toward the very end of the chopping operation.



Fig. 33 THE MEAT EMULSION IS FORMED WHEN THE PROTEINS ARE SOLUBILIZED AND THE FAT PARTICLES SUSPENDED AND ENTRAPPED WITHIN THE PROTEIN MATRIX. THE FINISHED EMULSION IS TRANSFERRED TO A STUFFER

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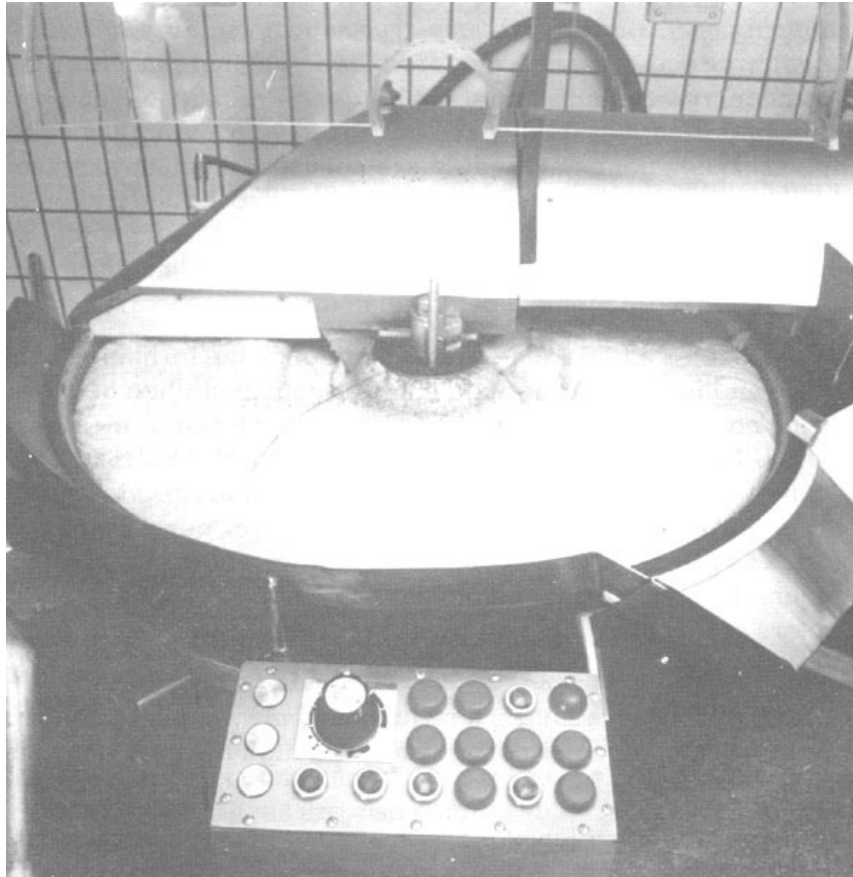


Fig. 34 THE EMULSIFICATION PROCESS IS TERMINATED; ALL WATER IS TAKEN UP BY THE DISINTEGRATED AND HOMOGENIZED MEATS

(Photo courtesy of Kraemer und Grebe, GmbH & Co KG. D-3650 Biedenkopf-Wallau, W. Germany)

Preparation procedures which provide for one-phase simultaneous meat and fat cutter treatment are increasingly popular.

The polyphosphate and curing ingredients should be dissolved in a small quantity of warm water before being added early enough to enable the effect of polyphosphate on actomyosin and the action of salt and nitrite on water binding properties and colour of meat. With the higher salt content and the longer cutter process, more salt soluble proteins are extracted and the binding quality of the finished product is improved. If hot boned meat is used, the addition of phosphates is not necessary.

Impact of the chopping operation on emulsion-type sausage quality.

Two types of emulsion-type meat products are generally produced. One type includes the all-meat products and the other type contains non-meat binders. Frankfurters and other emulsion-type sausages of higher quality are produced with a very low concentration of nonmeat additives. When nonmeat binders are not used, the natural proteins are relied upon to impart a suitable texture to the comminuted product. It should be emphasized that consideration must be given to the amount of lean meat to provide the protein: when the formulation contains a large amount of variety meats and other low bind materials, maximum extraction of skeletal lean meat is necessary.

There are many variables and parameters that influence the formation of meat emulsions. Moisture and fat binding depend chiefly on the condition of the raw materials and on the

comminution and mixing process in the cutter, the decisive factor in the success of frankfurter manufacture being the heating of the mixture during grinding in the cutter. The emulsifying capacity of salt soluble proteins is an important attribute of meats to be used in sausage preparation. This property is not static since several factors, such as pH, protein concentration, ionic strength and nature of neutral salts have been found to have a profound effect on the emulsifying capacity of proteins. Some of these factors are, in turn, affected by postmortem handling and processing conditions.

Rapid postmortem glycolysis results in a reduction in myofibrillar and sarcoplasmic protein extractability. Use of off-condition meats with a high bacterial load also can seriously reduce emulsification.

Adequate mechanical comminution of the lean meat is an essential factor in the binding of an emulsion but it can be a

disadvantage to comminute too intensively because the comminuted connective tissue could cause structural deterioration of the product. Furthermore, if the finished sausage mixture is comminuted too finely after adding the fat, this regularly results in faulty products. This is because too long a process and/or high temperatures cause the already finely divided fat particles to come together again, forming large islands of fat, and then to separate during subsequent heat treatment. On the other hand, if the emulsion is overchopped, the fat globules become too small having a very large surface area so that there may not be enough protein to emulsify all the fat. Such emulsion breaks down and yields a poor product.

The cutter time is preferably determined by an end-point temperature. In modern emulsion-type sausage manufacture, meats chilled at 0–4°C and frozen meats are interchangeably used. The temperature of the mixture during the cutter process is recommended not to exceed 12–14°C. Beyond 18°C further

cutter operations may contribute to poor stability with release of the fat and/or juices during smoking and chopping operations. It is assumed that at a mixture temperature of 18°C, the temperature in the area around the knives will be up to 60°C and 70°C. These high temperatures cause coagulation or denaturation of proteins. When phosphates are used, the firmness of the product fails at a temperature above 20°C.

Frequently, sausage manufacturers experience greater difficulty in emulsion destabilization with all-beef or mutton frankfurters, the main reason being that beef and mutton fats melt at a higher temperature than pork fat. To form a stable emulsion, these fats must be chopped to a somewhat higher temperature, especially if the raw materials are derived from older buffalo or zebu cattle. This is because the meats of older animals have less salt soluble proteins but their emulsifying capacity is more efficient.

To produce a finer texture, the mixture can be passed through an

emulsifying mill. As this operation is accompanied by a rise in temperature of 2.5–4.5°C, the initial temperature of the mixture prior to the emulsifying process should be below 10°C. On the contrary, an increased temperature can reduce the stability of the emulsion.

During or following cutter operations, the emulsion may also be vacuumized; the removal of air contributes to the stabilization of cured colour and enables better stuffing.

Emulsion destabilization is rare in a routine meat packing operation. Nevertheless, emulsion destabilization still remains one of the concerns in the meat processing industry, especially when new sources of protein and ingredients are incorporated or when inevitable changes in the processing system occur.

Hot meat processing.

Deboning and processing of hot meat largely avoid weight loss from evaporation which occurs in chilled meats. There are, however, possible disadvantages with hot deboning. The sticky nature of hot meat may increase bacterial contamination but this belief has not been fully confirmed. On the contrary, there is some evidence that viable counts of prerigor ground meats are similar to those of postrigor meat; their shelf-lives are also comparable both at the time of fabrication and after storage. Nevertheless, it should be emphasized that higher temperatures associated with possible delay in processing may have considerable adverse effects on the product's microbiological quality and this fact requires great attention. Immediate and well-organized processing operations and a high level of hygiene and cleanliness of machines and tools help to avoid this problem.

A serious risk in using prerigor meat is the possible delay in its deboning and chopping/salting. In any case, if the emulsion is prepared three or more hours after animal slaughter, the original

meat phosphates can be exhausted and an actomyosin complex formed. The amount of extracted myosin may then be highly reduced and an imbalance of myosin to water may result. The reduced amount of protein solution cannot bind all the water and coat of the fat globules and the finished product will be shrunken and covered with grease. Overchopping or a low content of lean meat usually unites in producing this effect.

If prerigor meat processing is accepted, chillers no longer have to be able to cool whole beef sides and can be replaced by relatively small purpose-built units which provide quicker and more economical chilling of other meats.

Preblending of prerigor meat.

Preblending of ground prerigor beef with ice and curing salts 10 to 20 hours before further processing has successfully been practised for many years. In the time interval between

preblending and further processing, the finely homogenized mass was kept under refrigeration (2 to 6°C) in shallow pans about 15 cm deep. A modification of this method includes the direct addition of pork components and spices in the emulsified meat mass followed by stuffing, with a rest period in the chiller for not more than 8 to 10 hours to cure before smoking. This practice is no longer fully justified since, with the use of ascorbate, the heat of the smokehouse can be relied upon to develop curing.

Emulsified fat batters.

A sausage emulsion may be considered as an emulsion in which fat is dispersed more or less uniformly in a continuous highly hydrated protein matrix. The fat droplets do not necessarily remain globular and they may coalesce with each other, but they cannot escape from the matrix to produce a single phase.

The desirable properties of emulsion-type sausages are largely determined by the stability of moisture and fat binding in the highly hydrated gelable protein matrix. Fat is an essential component of formulated meat products because it improves tenderness, juiciness and overall palatability. Thus, in a two-component system of fat and lean meat, fat is nearly equally as important as lean meat for desirable properties. For example, when the sausages are made with a very low fat content (less than 15 percent), they are usually tough unless enough moisture is added to compensate for the desired degree of tenderness. On the contrary, in order to compensate for unsatisfactory amounts of extracted salt-soluble proteins and improve binding and emulsifying properties of low lean/high fat content sausages, milk or soy proteins may be added. Finally, lower quality sausages (luncheon meat style products), with a high content of nonmeat filler ingredients and moderate amounts of fat, usually contain starch to impart the necessary binding quality and elasticity.

In sausage manufacture, animal fats are sometimes separately emulsified in water by using sodium caseinate or by vegetable proteins (Tables 8, 9 and 10). These emulsified fat batters may be directly incorporated into finely comminuted sausages such as frankfurters or they may be chilled and diced into discrete particle sizes to create a desired visual effect in, for instance, mortadella sausages.

Table 8 PREPARATION OF EMULSIONS OF VEGETABLE OILS OR ANIMAL FATS (MELTED) FOR INCORPORATION IN EMULSION-TYPE SAUSAGES

Operation	Sequence of placing ingredients into the cutter bowl	
beginning of chopping	8 parts of water at 65–70°C	7 parts of water at 65–70°C
during chopping	1 part of caseinate and chopped until a homogenized mass is	1 part isolate (soy) and chopped until a homogenized mass is

	obtained	obtained
	6 parts of vegetable oils at 80°C	7 parts of animal fat at 80°C
at the end of chopping	2 percent of salt	
storage	2–4°C in pans	

Table 9 PREPARATION OF EMULSIONS OF PREHEATED FATTY TISSUE FOR INCORPORATION IN EMULSION-TYPE SAUSAGES

Operation	Order of placing ingredients into the cutter bowl	
beginning of chopping	7 parts of fatty tissue preheated at 65–70°C	9 parts of fatty tissue preheated at 80°C
during chopping	1 part of caseinate (of high viscosity)	5 parts of water at 80°C
	7 parts of water at 90–95°C	1 part of isolate (soy)
at the end of	until finely homogenized 2 percent of salt	

chopping	
storage	0–4°C/3–4°C in pans
incorporation in sausage mix	after 24 hours (after protein hydration)

Table 10 PREPARATION OF EMULSIONS OF CHILLED (0–4°C) FATTY TISSUE FOR INCORPORATION IN EMULSION-TYPE SAUSAGES

Operation	Order of placing ingredients into the cutter bowl	
beginning of chopping	5 parts of cold water	5 parts of fatty tissue
	1 part of caseinate or isolate and chopped until a homogenized mass is obtained	5 parts of water at 80°C
during chopping	5 parts of fatty tissue	1 part of isolate (soy)

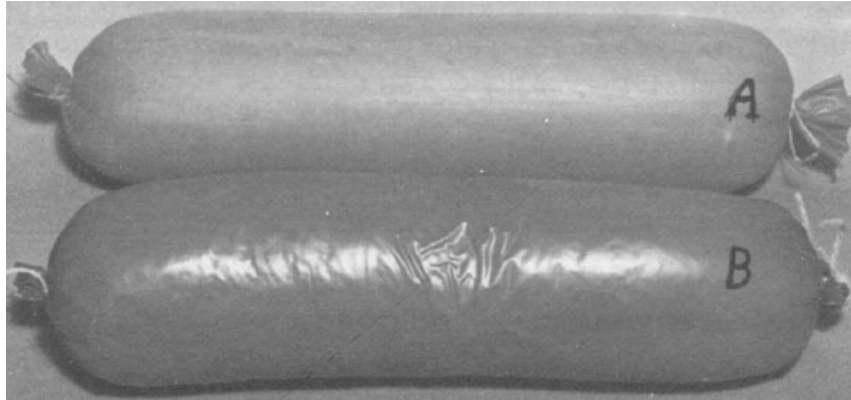
	until finely homogenized
at the end of chopping	2 percent of salt
storage	0–4°C/3–4 days
incorporation in sausage mix	after 24 hours (after protein hydration)

Methods of extending animal fats are of primary interest for small-scale sausage manufacture in tropical and subtropical areas of the world. Fat batters can have a basis of pork backfat, zebu boss, beef fat trimmings, etc.

Stuffing.

Raw sausage emulsion is encased either in artificial (cellulose or collagen) or in natural casings derived from slaughtered animals. Casings should be thoroughly selected in relation to the size and type. Frankfurters in natural casings appeal to some consumers

because of their appearance. The stuffing horn, which should have a diameter as large as possible to avoid smearing of the emulsion on the working table, must be absolutely clean. If cellulose casings are used, the surface of the table should be quite dry throughout the whole operation. Sheep and pig casings are flushed with water prior to being stuffed.



**Fig. 35 FILLING SAUSAGES MUST BE TO FULL CAPACITY (A)
UNDERFILLING RESULTS IN A SHRIVELLED PRODUCT (B)**

Filling must be to maximum capacity. Uniform stuffing of frankfurters and wieners is particularly important because they are often sold by piece and thus sausages of equal weight should be produced. A skilled operator should be capable of providing sausages that are substantially uniform in density and diameter.

Linking.

Sausages are tied or linked manually or by machine in fixed lengths. The use of machines for small diameter sausages is justified only when the size of operation is sufficiently large. In small-scale plants, the small sausages are divided by braiding, i.e. by twisting at desired intervals. The linking machines automatically divide multiple strands of stuffed sausages into links of predetermined length. The lengths are dependent upon market demand but often sausages for ordinary packs are 10 cm and for hot dog catering packs, 14 cm long.

The linked sausages are placed on smoke rods so that they do not touch each other and allowed to dry before smoking at room temperature for a period of one to two hours. This tempering period is especially important in the absence of an added reducing agent, such as ascorbic acid. If ascorbic acid is used in sausage formulation, heat processing may follow immediately after stuffing. Before entering the smokehouse, the sausages are washed with cold water. The use of properly shaped metal or wooden rods reduces the amount of surface coming into contact with the rods and prevents touch marks and spotting due to contact with adjacently hanging products thus contributing to a longer shelf life and better appearance of the final product.

In large sausages, such as bologna, stuffed casings are tied with thread or fastened with metal clips and suspended from a smoke rod so the entire sausage is not in contact with the rod.

Smoking.

The sausages on the smoke rods are transferred to the smokehouse. For smoking of emulsion-type sausages, so-called “hot smoking” is practised. It is well known that the composition of smoke volatiles is undoubtedly changed at different processing temperatures. At higher temperatures the smoke carries over more of the tar-like substances and large carbon molecules as well as different phenol compounds into the smokehouse atmosphere. Lower temperatures condense out these substances. High humidity or wet sawdust contributes to a dark coloured sausage.

Smoke composition also depends upon other factors such as the type and quality of the wood, temperature of combustion, relative humidity, air flow, etc. Resinous woods impart an unpleasant flavour to meat. Soft woods produce a large amount of soot that colours the product. Soft woods are only used if special flavour effects are desired. Because of their low resin content, hardwoods (oak, beech, maple, birch, walnut, cedar, hickory,

etc.) are most commonly used to generate smoke. However, different woods give forth different amounts and density of smoke. Mixtures of hardwood sawdusts are generally considered to give the best smoke composition. Sawdust, especially if green, is often wetted down, and forced air circulation and damp are necessary to control the burning process and composition of smoke.

Each major category of smoke compounds (acids, aldehydes, and phenols) is active in a particular phase of the hot smoking process. Acids coagulate muscle proteins. Aldehydes interact with protein molecules, linking them together to form a strong net. Smoke, high in aldehydes, contributes to stabilization of the sausage surface. Numerous studies have indicated that phenols are mainly responsible for the smoke aroma and taste of smoked meat. These reactions, each contributing to product quality in varying degrees, are speeded up at higher temperatures and are delayed at lower ones thus being predominantly brought into

play during the hot smoking process. Acids and other smoke components are also beneficial in causing skin formation on the surface of sausages by penetrating the cellulose casing long before heat coagulation occurs. Smoke penetration may be somewhat greater when natural casings are used.

The bacteriostatic and fungistatic effects of smoke depend on the level of the smoke production temperature which is usually varied between 300 and 400°C.

Smoke imparts flavour-sustaining properties to sausages. The higher the level of smoke density, the more pronounced the flavour, even after weeks of storage.

During the tempering period which precedes hot smoking, the curing process is often initiated. If this is not the case, the initiation of curing may be hastened by mild heating, with or without smoke, at approximately 40–45°C. This preliminary

heating may be omitted if the curing process is already sufficiently advanced. The duration of smoking depends on many factors. In the next phase, smoking continues at a slowly increasing temperature (65°C) until curing has progressed, i.e. until the inside colour is fully developed. In the following phase of the smoking process, the sausages are heavily smoked at a temperature of about 70–75°C, resulting in the desired surface colour of the commercial product. At the same time, the coagulation of proteins begins and their binding and setting come into play contributing to the required qualities of the final product. If sausages are artificially coloured, lighter smoking may be preferred.

During the hot smoking process, the relative humidity should be maintained at about 80 percent. A too low humidity causes the formation of a dehydrated protein shell on the sausage surface as well as excessive weight loss and shrivelled appearance of the product. It happens basically during the first phase of smoking.

At the same time, it should be emphasized that as the relative humidity in the smokehouse increases, smoke tends to dilute which contributes to a lightly smoked product. This can be overcome by increasing smoke density but the best solution is to determine the optimum density of smoke desired for a specific product at the highest level of relative humidity, not adversely affecting the surface colour.

High temperature smoking normally shortens the time of smoking providing the sausage manufacturer with the opportunity to increase his smokehouse throughput. However, processing in a too hot smokehouse induces weight loss and rupture of cellulose casings, while too cold smoking hardens the casings.

Liquid smoke.

Liquid smoke is a water soluble chemical solution containing smoke flavour which can be sprayed on the sausages while they

are in the smokehouse. Liquid smoke is produced by the condensation and fractional distillation of hardwood smoke. Liquid smokes are free of carcinogenic compounds. They offer complete uniformity, resulting in less maintenance and cleaning.

Many meat processors feel that they cannot obtain the same flavour with liquid smoke as they can using smoke generators. This is the reason why this preparation has only limited application in today's meat processing industry.

Cooking.

Cooking or scalding follows immediately after smoking. There are many methods of cooking: by immersing in the cooking vat, hot showering that is conducted in a smokehouse equipped with shower nozzles, hot showering in separate hot water spray cabinets to which sausages are moved immediately after smoking, cooking by dry heat by raising the smokehouse

temperature and giving only a final brief hot water shower, cooking in tight boxes into which live steam is injected, etc.

Cooking schedules vary markedly. If water sprays are used the temperature is about 80–82°C. The temperature of water in cooking vats may be about 73–76°C. A final internal sausage temperature of 65°C is considered as minimum but a temperature of 68°C is an optimum end-point temperature providing a sufficient shelf life of the product and desired organoleptic characteristics. This requires usually about 15–20 minutes. The right cooking schedule should be developed by carefully studying the yield and quality of the sausage. After cooking in vats, sausages are hot showered to remove any adhering grease.

The total smoking and cooking time is dependent on the progress of the curing process in the product: if conditions for its full development are optimum, the smoking and heating period may take no more than 1–2 hours but it can be as long as 2–3

hours.

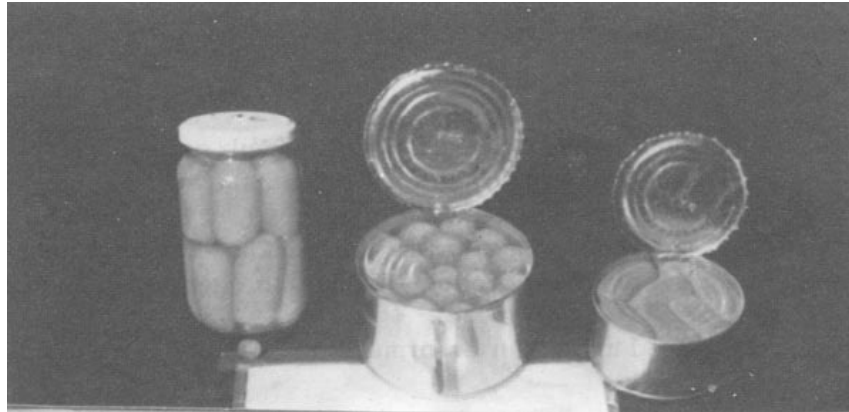


Fig. 36 EMULSION-TYPE SAUSAGES MAY BE SUCCESSFULLY CANNED AND KEPT FOR A LONGER TIME (*Photo courtesy of Dr M. Marinkov*)

Chilling.

Chilling by cold water spray (16°C) is applied at the end of the thermal processing schedule to cool frankfurters to slightly

above room temperature before placing them in a 1–4°C cooler for final chilling.

1. FRANKFURTERS (Wieners)

The most popular sausages are frankfurters. They are either pork and beef or all-beef products. The frankfurter formulations often contain different filler meats such as hearts, giblet and weasand meats, tripes, tongues, snouts, lips, etc. It is generally agreed that filler meats should not exceed 20 percent of the meat formulation. Nonmeat binders are also added in low cost formulations.

Traditional meat precuring has nowadays been abandoned and generally replaced by stuffed sausage curing.

Frankfurters prepared from prerigor raw materials are more acceptable in appearance, flavour and juiciness and more

desirable than sausages prepared from postrigor meat. Desirable sausage-making qualities of prerigor beef can be maintained by preblending raw material with 3 percent of curing nitrite salt (or 3 percent of salt plus 60 ppm nitrite), minimizing exposure to air and storing at 2°C for up to 2–8 days.

Hot beef wiener production has its roots in at least two centuries of history. Although there is no exact documentation of where the first emulsion-type sausage was produced, there are some indications that it was done by the Vienna sausage producer, Johann Georg Lahner, in 1805. According to other sources, it is more likely that the production of frankfurters began much earlier in the 18th century and that this history continued in an unbroken line to several decades ago.

FORMULATIONS

As a rule every successful sausage manufacturer has his own

formula or recipe for frankfurters. The following formulae may be used as a starting point and varied to suit the desires of the market. Binders which may be used, if permitted by regulations, are 1.2 percent of soy or milk protein, 0.3–0.5 percent phosphate, 3 percent wheat flour, 3 percent potato starch, etc. Frankfurter formulations with 1.5 percent wheat flour and 1.5 percent potato starch give a product which is more tender than those made only with starch or flour.

Prepared fat batters can also be used in frankfurter formulations.

Basic ingredients for 100 kg

- a. 35–50 kg beef
35–50 kg fat beef or pork trimmings
15 kg ice**

- b. 33 kg beef**

52 kg fat beef or pork trimmings, pork jowls, etc.

15 kg ice

c. 50 kg pork trimmings

25 kg tripe

25 kg beef head meats

d. 75 kg beef 10 kg beef 15 kg ice or cold water

e. 40 kg lean beef trimmings

45 kg pork trimmings

15 kg crushed ice

f. 30 kg bull meat

25 kg lean pork

25 kg porkjowl

20 kg crushed ice

Cereals, nonfat milk solids, corn syrup solids and other nonmeat

ingredients may be used to the extent permitted by local regulations. Partial replacement of meat with soy or other plant proteins in frankfurter mixture systems is being increasingly accepted. Soybean proteins especially are a logical and economical substitute for meat because their amino acid patterns are similar to beef except for slightly higher phenylalanine and lower methionine.

Characteristic seasoning formule per 1 kg (see Table 4)

- a. 20.0 g curing nitrite salt**
- 0.2 g sodium glutamate**
- 2.1 g white pepper**
- 0.6 g red pepper**
- 0.3 g dextrose**
- 0.5 g mace**
- 0.3 g cardamom**
- 0.3 g ginger**

0.3 g allspice

0.1 g ascorbic acid

b. 23.0 g curing nitrite salt

0.5 g corn syrup

0.5 g sugar

0.3 g lemon bark

2.5 g pepper

0.5 g nutmeg

0.2 g sodium erythorbate

c. 23.0 g curing nitrite salt

0.4 g sodium nitrite

2.3 g white pepper

0.2 g coriander

0.1 g chili

0.1 g sage

0.4 g nutmeg

0.3 g garlic
1.0 g mace
3.0 g sugar
0.4 g sodium ascorbate

- d. 18.0 g curing nitrite salt**
2.0 g white pepper
0.5 g red pepper, sweet
0.6 g mace
0.4 g caraway seed
0.3 g cardamom
0.4 g allspice
0.2 g monosodium glutamate
0.1 g sodium ascorbate (erythorbate)

Instead of the above-mentioned spice combinations, commercial ready-mixed spice formulations from specialized suppliers may be used. Similarly, in lieu of the prepared curing mixture

specified above, nitrite and salt in the same appropriate ratio may be added (see “Nonmeat ingredients”).

Casings

Artificial or natural

Processing and handling

In preparing frankfurter emulsions, the beef components are usually ground or chopped first with the dissolved curing ingredients, seasonings and water. This is followed by the pork and fat additions and the mixture is reduced to the desired degree of fineness. If ascorbate or erythorbate is used, the required amount is added in solution approximately one minute before the end of the chopping process. End-point chopping temperature depends on the raw material used, the type of the cutter and other factors. The finished emulsion is often passed

through an emulsion mill to improve fineness.

The most successful wieners are manufactured from prerigor beef chopped in the cutter with curing nitrite salt. The emulsion is then placed in shallow pans for 1–2 days for curing. After curing, the emulsion is remixed together with pork and other ingredients and filled into narrow sheep casings (22 mm in diameter).

The stuffed frankfurters or wieners are either linked or simply looped over smoke rods. Frankfurters may be successfully smoked in a number of different cooking schedules. Normally, they require a total continuous processing time in excess of three hours. The starting smoking temperature is generally about 43°C, at the end of a one-hour period it may be increased to 55°C, and then it is raised to 78–82°C and maintained for the balance of the smoking period, i.e. until desired internal temperature is achieved. If the frankfurters are cooked in a

controlled atmosphere smokehouse, it should be done according to a schedule designed to reach the prescribed final internal temperature of 71°C. An alternative frankfurter thermal processing schedule may consist of a one-hour period at 55–60°C and then a period of 45 minutes at 70°C, followed by a smoking period of 80–85°C until the internal temperature of the product reaches the desired level.

After the frankfurters acquire a brown smoked colour and a finished appearance, they are precooked either in a cooking vat or in a water spray. An internal temperature of 68°C should be considered a minimum end-point temperature in warm climatic regions. An internal temperature of 70–71°C will provide better keeping qualities.

Immediately after precooking, the sausages are cooled with cold water and maintained firm, dry and in a good condition. The frankfurters can be kept in a chillroom or held at - 18°C until

used. If they are produced in cellulose casings, the frankfurters should be peeled. The yield of frankfurters after precooking should not be more than 110–115 percent of the weight of the beef and fat incorporated in the mixture.

***Peeling.* Peeling of the skin is one additional step required for frankfurters processed in cellulose casings. A number of factors influence the peeling characteristics of the product. Processing conditions must be regulated to give proper drying and coagulation of the sausage surface in order to provide a firm skin which is not easily ruptured. Understuffing may be the cause of improper skin formation and overstuffing results in good skin formation but presents other handling difficulties and may cause breakage.**

For proper peeling some moisture is required between the sausage and casing. Moving chilled sausages to a somewhat warmer room for peeling causes some condensation of moisture

and frequently improves peeling characteristics. A fine water mist on the product prior to peeling serves the same purpose.

2. BOLOGNA

Like frankfurters, bologna is also an emulsion-type product that is stuffed in a large casing. Beef bologna is made with a mixture of beef, mutton and veal or it is 100 percent beef; buffalo meat can also be successfully used. Beef and pork bologna is usually formulated using a 60:50 or 50:50 ratio of beef to pork containing about 30 percent total fat.

An amount of 1.5–2.0 percent of approved sausage binder may be added in the cutter with beneficial results.

FORMULATIONS

Basic ingredients for 100 kg

a. pork-beef bologna**45 kg pork****37 kg beef****18 kg ice****2 kg milk (or soy) protein****b. all-beef bologna****20 kg beef weasand, hearts or giblets****30 kg beef trimming****25 kg beef****10 kg beef fat****15 kg ice****2 kg soy (or milk) protein****c. low cost bologna****30 kg beef trimmings****20 kg beef hearts, tripe****10 kg pork stomachs**

20 kg pork fat
15 kg ice
5 kg wheat flour

Characteristic seasoning formulae per 1 kg (see Table 5)

- a. 20.0 g curing nitrite salt**
 - 0.8 g mace**
 - 0.5 g caraway seed**
 - 0.5 g red pepper**
 - 2.0 g pepper**
 - 0.3 g marjoram**
 - 0.5 g ginger**
 - 0.4 g coriander**

- b. 20.0 g curing nitrite salt**
 - 2.0 g sugar**
 - 0.3 g sage**

2.5 g white pepper
0.5 g mace
0.2 g coriander
0.2 g sodium glutamate
0.1 g sodium ascorbate

- c. 22.0 g curing nitrite salt**
3.0 g dry corn syrup
3.0 g pepper
0.2 g cardamom
0.5 g fresh garlic
1.5 g red pepper
0.3 g sodium glutamate

- d. in all-beef products the use of garlic, thyme and sweet bay is considered typical**

Casings

Natural (beef middles, bungs or rounds) or artificial (fibrous and other) casings in corresponding sizes, usually 4.5–5.0 cm in diameter, are used.

Processing and handling

The emulsion is prepared in the cutter as described in the instructions for emulsion-type sausages'. The stuffed product is placed in the smokehouse for 6–8 hours starting with a temperature of 55°C (damper open) for about 30 minutes which is slowly increased to 80°C or until the internal temperature reaches 69–71°C. The product should be immediately chilled with a cold water spray for at least 45 minutes and kept under refrigeration.

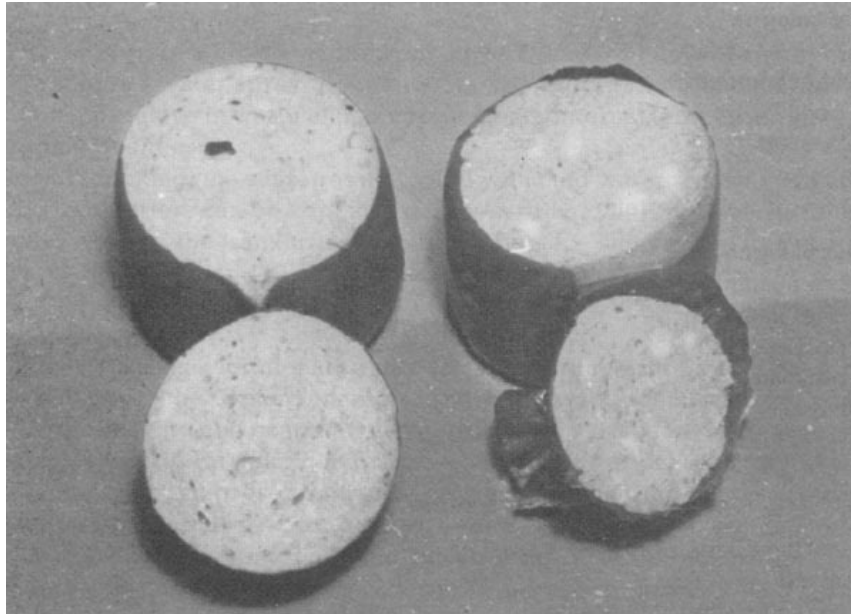


Fig. 37 THE OCCLUSION OF AIR IN THE BOLOGNA MIX CREATES POCKETS OR VOIDS WHICH ARE RETAINED IN THE FINAL PRODUCT

3. MORTADELLA

The meat formulations for mortadellas vary widely. Often commercial mortadella sausages are formulated with a lean mix of not less than 65 percent of beef and 33 percent of pork.

The seasoning used in mortadellas plays a very important role in the final product quality. The high quality mortadellas are usually flavoured, among other spices, with coriander seeds, allspice and pistachios; white wines are also often added in the mixture prior to stuffing.

FORMULATIONS

Basic ingredients for 100 kg

- a. 40 kg lean pork**
- 30 kg pork bellies**
- 15 kg pork jowls**
- 10 kg backfat cubes immersed in hot water**

5 kg crushed ice

b. 32 kg lean beef

25 kg pork belly

15 kg tripe, weasand and giblelet meats

10 kg pork jowls

10 kg protein extended fat batters

5 kg crushed ice

3 kg protein binder

Characteristic seasoning formula per 1 kg

20.00 g curing nitrite salt

2.0 g red pepper, sweet

0.6 g nutmeg

0.4 g ginger

0.3 g cardamom

0.2 g glutamate

0.4 g coriander

0.2 g sodium ascorbate

Casings

Wide beef bungs or bladders or artificially made casings in corresponding sizes.

Processing and handling

The lean mixture is produced in the manner described in the previous instructions. The point which should be noted is that protein extended fat batter cubes are added in the cutter, when the chopped mixture is nearly fine. The same is done if diced pork backfat is used and the composite is then mixed by hand or in a mixer.

After stuffing, sausages are smoked for 6–8 hours, first in hot smoke between 40 and 50°C and then in a dense smoke until a

golden yellow colour develops on the surface of the product. Mortadellas are then cooked at 80–84° or until an internal product temperature of 69°C is reached. After removal from the smokehouse, mortadellas are cold-showered for not less than 30 minutes and chilled overnight in a 0–4°C chiller.

4. CHICKEN FRANKFURTERS

In recent years significant advances have been made by the poultry processing industry in the development of additional processed items including products such as frankfurters or bologna. Chicken and turkey frankfurters are today popular poultry meat products. They are made from meat which should be free from bones, tendons and often skin.

The methods of processing are essentially the same as for other emulsion-type products.

FORMULATION

Basic ingredients for 100 kg

80 kg chicken or turkey meat

10 kg chicken fat

8 kg ice

**3 kg nonfat dry milk or soy protein or wheat flour or rice flour,
etc.**

Characteristic seasoning formula per 1 kg

18.0 kg nitrite salt

1.2 g red pepper

2.0 g dextrose

1.5 g black pepper

0.5 g coriander

0.2 g monosodium glutamate

0.5 g thyme

0.4 g phosphate

Casings

Cellulose fibrous casings and many types of plastic casings but sometimes natural casings are also used.

Processing and handling

Chicken or turkey meats are first placed in the cutter bowl followed by phosphates dissolved in a small amount of water. Other ingredients are then added in selected proportions to obtain the desired fat level. The stuffed sausages are heat processed in the same way as other frankfurters. The optimum internal temperature at the end of processing should be about 68°C. After cold showering, frankfurters are kept under refrigeration temperatures.



Fig. 38 IN BONING POULTRY CARE SHOULD BE TAKEN TO REMOVE ALL CARTILAGE AND BONE. SKIN, FAT AND MISCELLANEOUS PIECES OF DEBONED POULTRY MEAT CAN BE GROUND AND PROCESSED IN FRANKFURTERS.

5. BASIC FORMULATIONS FOR SELECTED EMULSION-TYPE SAUSAGES

Formulations for some other emulsion-type sausages are given in Table 11.

Table 11 BASIC FORMULATIONS FOR SOME EMULSION-TYPE SAUSAGES

Sausage	Beef %	Fat %	Ice %	Spices¹
caraway	30 plus	30 pork fat	15	caraway (1.0), mace,
sausage	10 lungs	15 beef fat		coriander, ginger, glutamate
garlic	65	15 beef fat	20	coriander, rosemary, garlic (1.2 g),

sausage			caraway etc.
cheese sausage	95 all-beef emulsion plus 5 low fat cheese	+	as for frankfurters
heart sausage	80–85 all-beef emulsion 15–20 cured pork or lamb or veal hearts		as for bologna plus pistachios
red pepper sausage	50 all-beef emulsion plus 50 pork belly		3.5 red pepper, 1.0 allspice, 0.2 chili, 0.3 garlic

¹ addition of 1–3 g/kg is practised in all formulations





COOKED SAUSAGE PRODUCTION

The manufacture of cooked sausages is a natural adjunct to any meat selling and processing business. Cooked sausages offer an outlet in attractive and palatable form for a variety of raw materials such as edible portions of heads, mutton, pork or beef trimmings, blood, hearts, tripe, livers, lungs, pork stomachs, tongues, various fat materials including those of zebu cattle boss or mutton fat tail as well as other cured or uncured meats that are difficult to dispose of in any other way.

The proper handling and use of edible by-products is of much importance in developing countries where the hygiene standard must be raised. Being highly perishable, edible by-products suffer greatly when there is undue delay between cleaning and

processing operations. Every endeavour should be made to have offals carefully handled within the slaughterhouse immediately before they leave the killing floor. The sausage manufacturer may accomplish this in several ways for which speeding up delivery of products to the plant, reducing the number of suppliers and providing facilities for the immediate cleaning and preliminary washing of all by-products in the slaughterhouse seem to be essential.

The trimming of excess fat and inedible connective tissue parts and other operations of by-product pretreatment should take place as soon as possible after slaughter of the animal. If the raw materials are to be chilled before use, this should follow immediately.

Cooked sausages are distinguished from other sausage categories not only on the basis of variety of materials used in their formulations but also by parboiling or partial cooking of

most of these raw materials prior to grinding or chopping. The cooking schedules vary with the nature of the raw materials, the age of the animal and the characteristics of the product desired. Some organs, for instance livers, are only scalded.

Raw materials rich in connective tissue, such as heads, are cooked until the meat separates from the bones; the meat obtained is usually chopped very finely in the cutter. The fact that cooking losses from quality lean meats tend to be higher than from poor quality connective tissue-rich meat must be considered.

The ground, usually precooked, raw materials are mixed according to their leanness and fat contents with the corresponding salt quantity, and a portion of broth or water of about 10 percent may be added. After mixing for 3 to 7 minutes manually or in the double-wave mixer, the salt is dissolved and the ingredients are sufficiently homogenized due to the

continuous pushing and mixing effect.

Protein emulsifying agents (sodium caseinate or soy protein preparations) are increasingly used in some cooked sausage products. The addition of an emulsifier stabilizes the emulsion and helps in binding the components more firmly together giving the product a firm homogeneous consistency; it contributes also to a more attractive colour and ensures typical spreading properties (see “Sausage raw materials”).

In the production of cooked sausages, it is necessary to use casings having very low moisture vapour transmission and very low oxygen transmission rates. The sausage mix is stuffed into natural or artificial casings. It is obvious that sausage stuffing and linking are very important precooking operations. The occlusion of air in the sausage mix creates pockets or voids which are retained during the following operations. This promotes volumetric and weight nonuniformity in the sausage as

well as other undesirable results.

Cooked sausages may or may not be smoked following cooking.

There are numerous cooked meat specialities produced in the same manner as cooked sausages. Many of these specialties are not stuffed into casings but they are shaped in metal or other type containers or moulds. Such cooked items are luncheon meat, head cheese, numerous jellied products etc. Loaves are cooked in moulds and placed in casings or they may be cooked in casings. The cooking is done in a hot water bath but baking in an oven is also applicable.

The following are the formulae and methods of preparation of cooked sausages which have been verified to give satisfactory results.

1. LIVER SAUSAGES

Liver sausages include many varieties and are made in accordance with widely varying formulae. Liver sausages are basically ground meats, liver and fat to which may be added various cured meats, by-products or nonmeat ingredients, such as spices (Table 6), milk powder, phosphates etc. Not only pork but also beef and mutton livers are excellent raw materials in liver sausage manufacture.

Raw materials used in liver sausage preparations are usually parboiled or cooked before being chopped, mixed and filled into casings. Livers are used either previously cooked or raw. The preparation of livers is of particular importance. Several narrow cuts are made across the liver extremities to facilitate blood and gall extraction. Removal of the bile ducts and large blood vessels is a decisive factor determining the eating quality of the product. There seems to be no difference in processing hot livers immediately after slaughter or chilled ones.

All types of fat can be incorporated in liver sausage emulsions but generally carcass fats are preferred. Internal or body fats, however, can also be processed. Fat material, particularly internal fats, must be washed in cold water, classified according to fat to lean ratio and chilled. Special care should be paid to eliminate factors enhancing oxidative changes.

By-products, including tripe, hearts, backfat, lungs, beef, veal etc. are widely utilized especially in low cost liver sausage formulations. All-beef liver sausages are made with beef and lamb livers. There are trends in reducing the amount of liver and increasing the contents of meat and fat ingredients.

Sausages containing more than 45 percent fatty tissue give a fatty impression in taste and in appearance. Sausages containing 30 to 42 percent of pork jowls or bellies have a pleasant meat-liver aroma. An addition of less than 25 percent of jowls or bellies results in a rough and dry flavour with an acceptable liver aroma.

Other body fat tissues should be used at lower levels. The processing of melted pork or beef fat instead of fatty tissue gives the same results: below 20 percent the product is often dry, above 40 percent the fatty appearance and taste become more pronounced.

Present day meat technology and up-to-date equipment used in liver sausage manufacture can guarantee not only a considerable storage life of the final product even in a tropical climate but also surprising economical conditions together with a high quality.

FORMULATIONS

Basic ingredients for 100 kg

- a. 40 kg pork liver
60 kg pork belly**

- b. 55 kg meat trimmings (pork, beef or mutton)**

25 kg fat

20 kg liver

(20–30 kg broth - concentrated jellied water in which raw material was cooked)

This formula gives the right percentage of fat, meat and livers to produce a firm mixture with a good spreading quality and rich flavour. A somewhat less firm but still well-spreading product can be obtained by a 10–15 percent increase of fat-to-meat ratio or by adding more broth or water.

c. 40 kg pork liver

30 kg pork bellies

15 kg beef

15 kg cheeks

(jellied water may be added)

- d. 20 kg liver**
11 kg lean pork
35 kg pork jowls
34 kg bellies
(jellied water may be added)

- e. 30 kg liver**
10 kg veal
40 kg jowl
20 kg bellies
(jellied water may be added)

- f. 25–35 kg veal liver**
10–30 kg veal
10–20 kg veal head meats (feet)
10–20 kg beef (mutton) fat
10–20 kg tripe, lungs, hearts
(jellied water added)

In making low cost liver sausages 10–20 percent of the above materials may be substituted by hearts, backfat, lungs, tripe, cooked skins etc.

Characteristic seasoning formulae per 1 kg

Spices for liver sausages should be rigorously selected to give a mildly but delightfully seasoned final product with a distinctive tangy flavour. Liver sausages usually do not contain garlic (see Table 6). Some characteristic seasoning formulae are as follows.

- a. 24.0 g curing nitrite salt**
- 3.4 g white pepper**
- 1.3 g coriander**
- 1.2 g mace**
- 0.3 g cloves**
- 0.6 g marjoram**
- 0.2 g thyme**

45.0 g peeled onions

If a highly spiced and hot-to-the-palate product is preferred, chili and an increased amount of white pepper may be incorporated in the mixture.

b. 22.0 g curing nitrite salt**0.1 g vanilla****0.5 g allspice****1.2 g marjoram****2.0 g white pepper****0.2 g monosodium glutamate****0.2 g basil****0.5 g mace****40.0 g fresh onion**

(This formula is recommended for a beef liver sausage)

c. 20.0 g curing nitrite salt

2.5 g pepper
0.8 g nutmeg
0.1 g vanilla
0.3 g cardamom
0.2 g anise
0.4 g allspice
0.5 g ginger
30.0 g deep-fat-fried onions

d. 18.0 g curing nitrite salt

2.5 g pepper
0.4 g cardamom
0.5 g nutmeg
0.5 g ginger
0.1 g glutamate
2.0 g honey
0.1 g rosemary
30.0 g deep-fat-fried onions

Casings

Various natural or artificial casings of 50–65 mm are used.

Processing and handling

Basically, there are two main processing methods in manufacturing liver sausages: (a) hot processing precooked materials, and (b) cold processing precooked materials. The first method gives a finer, more spreadable product, using often less liver and more by-products. The second method results in a firmer product characterized by a richer liver taste and aroma.

a. Hot processing of precooked meats and fats

- 1. Parboiling of meats and fats. The meats are placed with the peeled onions and about one-third of the prescribed amount of salt in the cooker and cooked at a temperature not exceeding 80°C for 30 to 90 minutes. At**

the very end of cooking, the fatty tissues are added. To reduce or eliminate mutton or tallow odour, cooking should be sufficiently lengthy. The longer the cooking time, the lesser the amount of retained odour. The meats are normally cooked until they are so tender that the bones can be easily removed.

The broth is left to settle for a while after the meats and fatty tissues have been removed and the grease is skimmed from the top. The broth is then concentrated by boiling, clarified by passing through a cheesecloth and used when still hot (60°C) according to the accepted formula.

- 2. Disintegrating and homogenizing liver. Raw livers with one-half of the prescribed amount of salt are comminuted in the cutter until a dark semi-liquid mass is obtained. As soon as air bubbles start to appear, the**

machine is stopped and the liquid liver is removed from the cutter and kept until used.

- 3. Disintegrating, homogenizing and emulsifying liver sausage ingredients in the cutter. The meats after being cooked and the fats scalded are placed together in the cutter bowl and roughly disintegrated using the first speed of the cutter. The second speed of the cutter is then switched on and the remainder of the salt is added until the mass is finely homogenized. If soy or milk proteins are used, the addition of one-half of the prescribed amount should be done at the very beginning and the second half at the end of the operation.**

The hot broth, i.e. the water in which the meat and fat were cooked, is added gradually during the operation in such a way that the temperature of the whole mixture is maintained constantly at 58–60°C (final temperature

should not be less than 45°C). When the mass is thoroughly homogenized, the liquefied liver is added and when well distributed usually after 6–8 revolutions of the bowl, the raw liver sausage emulsion is ready. In order to improve the flavour, an amount of deep-fat-fried onion may be added to the mixture during the last rotations of the cutter. The raw liver sausage mass may be passed through an emulsifying mill, if desired.

- 4. Temperature of emulsion. The temperature of meat ingredients used in processing is a decisive factor in liver sausage production. Meat and fatty tissue must be heated to above 65°C to melt fat and denature proteins. Raw livers should be added when the temperature of the meat-fat mixture falls below 60°C to avoid liver protein denaturation but the temperature of the emulsion must not be below 45°C to ensure melting of fat.**

- 5. Stuffing. When homogenized, the emulsified raw liver sausage mixture is placed in the cylinder of the stuffer. If raw livers are being used, the casings must not be stuffed too tightly because the raw livers expand when cooked.**

- 6. Cooking and smoking. The products are usually cooked at 80°C for about 60–90 minutes. A point which should be made clear is that high cooking water temperatures may produce jelly pockets in the finished product. Some products are cold smoked for one or more hours.**

- 7. Storage. After the liver sausages have been cooked and cooled, they are transported to the cold store at 0–4°C.**

b. *Cold processing of precooked meats and fats*

Alternatively, especially if a firmer higher-value final product

is wanted and the amount of liver used is sufficiently large, the cooked meat and scalded fat, after chilling, are placed in the cutter together with other ingredients and thoroughly chopped until a fine emulsion is produced. A good result depends on thorough chilling of precooked material to a temperature below 25°C and the use of a sufficiently potent cutter. All other operations are identical to those mentioned under (a).

2. BLOOD SAUSAGES

All meat raw materials used in the manufacture of blood sausages, with the exception of fatty tissue and blood, are previously cooked. As their cooking times differ, they have to be cooked separately. Fatty tissues are only scalded and usually diced.

After cooking, the meat materials are coarsely ground and mixed

with the other components prescribed in the formulation.

FORMULATIONS

Basic ingredients for 100 kg

- a. 25 kg blood**
40 kg pork jowls
25 kg pork belly
10 kg skin (veal or pork)

- b. 30–60 kg pork skin**
25–35 kg pork blood
10–35 kg pork backfat

- c. 10–15 kg skin**
20–30 kg blood
20–30 kg veal feet (cooked and deboned)
10–15 kg fat or brisket fat

15–20 kg veal or lamb

Characteristic seasoning formulae per 1 kg

- a. 22.0 g salt**
 - 2.4 g pepper**
 - 0.6 g allspice**
 - 5.0 g onion**
 - 0.5 g cloves**

- b. 20.0 g salt**
 - 2.5 g pepper**
 - 30.0 g onion**
 - 0.5 g allspice**
 - 1.0 g cloves**
 - 0.5 g nutmeg or mace**
 - 2.5 g marjoram**
 - 0.5 g mace**

Casings

Beef bungs and middles or corresponding size of artificial casings are used.

Processing and handling

a. Conventional blood sausage

Pork skin and other kinds of skin, onion and meats are chopped together in the cutter for quite a short time and, after the addition of blood, chopping is continued to produce a fine mass. At the very end of the chopping process scalded diced fat (0.5–1.5 cm) and seasonings are placed in the cutter and evenly distributed in the mix. The cooking of the stuffed product is carried out at 83–85°C for about one hour and quickly chilled.

This blood sausage mix is often used as a matrix or

supporting medium in which some other components are added, thus forming an integral part of a new blood sausage variety.

b. *Tongue blood sausage*

This blood sausage variety is distinguished by the addition of cured pork, lamb or veal tongues in the blood sausage mix. Casings are loosely filled with blood sausage mix and two or three tongues are inserted lengthwise so that the tongue to blood sausage mix ratio is about 1.2:3.0. Another alternative is to cut the cured tongues into 3 × 4 cm pieces, mix them with the blood sausage mixture and stuff into beef bungs or corresponding size of artificial casings.

3. HEAD CHEESES

Head cheeses are usually defined as cooked meat specialties

stuffed and processed in pork stomachs or other natural or large diameter casings in a hot water bath. The composition varies widely but most commonly it includes pork or veal, pork head meats, including skins, snouts, pork underlips, veal feet, tongues etc.

The raw materials are previously cooked to a level dependent upon the nature of each individual component, then ground and/or chopped. The jelly water in which raw materials are cooked is concentrated by boiling and used to improve the flavour, binding properties and value of the final product. Commercial gelatine (1 kg to 8 kg of hot water or according to the specification given by the producer) may be used instead of the cooked water gelatine or instead of the skin.

FORMULATION

Basic ingredients for 100 kg

40 kg pork cheek, feet

20 kg snouts

10 kg underlips

20 kg head skin

10 kg tongue

Characteristic seasoning formula per 1 kg

23.0 g salt

10.0 g onion

3.0 g pepper

2.5 g marjoram

0.5 g allspice

0.5 g cloves

1.5 g caraway seed

Casings

Moisture-proof large diameter casings are used.

Processing and handling

All materials are thoroughly cooked and then chopped and mixed with the seasoning and jelly water remaining from their cooking. The stuffing into pork stomachs or in other types of containers should be loosely done to avoid the product breaking during cooking. Openings in the stomachs are tied and cooking is done at 73–74°C for about 90 minutes. The cooked product is immediately chilled under pressure to allow free water to escape and enhance the binding. Commercial gelatine may be added to facilitate binding.

4. MEATLOAVES

Blood sausages, liver sausages and head cheeses are often manufactured in loaf forms.

Meat loaves are often attractively arranged, decorated with red or green pepper, pistachio nuts, pickled cucumbers or other types of pickles and packed in characteristic moulds. Basic criteria used to judge the quality of this group of products are the overall appearance of the product, its firmness, delicacy of its flavour, fineness of its manufacture, composition and arrangement of different details, forms and colours as well as professional inventiveness.



**KEEPING QUALITY AND DELIVERY OF SAUSAGES TO
RETAILERS**

The distribution of sausages in tropical and subtropical regions should follow principles essentially similar to those applicable in temperate climates but practical details have to be modified according to local conditions. The complexity of the sausage nutritional and flavouring picture causes special relationships between customers and their sausage suppliers. The most successful marketing of sausages has now become a mutual effort between customer and sausage manufacturer. The customer needs to know what effects the sausages have for his health and what price he is obliged to pay. The sausage manufacturers have to know how to produce the desired products, requiring knowledge of meat and nonmeat sausage raw materials, their quality profiles, processing operations, required methods of storage and, increasingly so, the complex picture of supply.

An efficient sausage manufacturer should provide consumers with a flow of sausage products of the type, quality and amount

that are desired. In those cases where the sausage manufacturer is not properly informed of consumers' requirements or fails to pay attention to such information, consumers have little interest to buy his products and prices tend to be low.

New products and their marketing methods are gradually created and must be in harmony not only with customs, education and economical power of the public concerned but also with public health requirements.

KEEPING QUALITY

The major concern of meat processing in tropical and subtropical countries is the development of safe sausage products through the rational use of raw materials, adequate processing methods and maximum performance of hygienic requirements. From the processing plant to the sausage manufacturer a beef or pork carcass must have sufficient shelf life. Meat with the best shelf

life is the easiest ro process. The surest way to produce poor quality sausages is to process discoloured or in any other way spoiled meat.

The microflora of sausages is essentially different from that of carcass meat. Although particular problems arise with specific sausage products in general it may be said that for all sausages, three basic requirements must be for a hygienically satisfactory product: (a) conditions of sausage production must be such that should toxigenic organisms be present in or gain access to the product prior to, during or after processing, no bacterial toxins are formed, (b) the final sausage product should not contain microorganisms likely to be pathogenic to man, and (c) the total bacterial count of the sausage product should be reasonably low so that no decomposition or development of undesirable flavour occurs during the period of processing, distribution or storage. Special problems may arise if the sausages are to be held in particularly warm and humid conditions promoting bacterial

growth.

The first and second requirements mean in general terms that the meat raw materials should be free from toxigenic and pathogenic organisms and must be boned, trimmed, ground, chopped and processed at a temperature at which significant growth of these organisms is unlikely to occur; alternatively, the time of processing at an undesirable temperature should be shortened so that even if such organisms may be present, no significant growth or production of toxin occurs. The hygienic quality of a sausage product therefore has to be assessed primarily on freedom from pathogens, potential pathogens and their toxic products (sporing anaerobes, enteric organisms of typhoid, paratyphoid, dysentery and *Salmonella* groups and certain staphylococci and perhaps streptococci).

The third requirement demands the selection for sausage manufacture of sound good quality meats and other raw

materials and the observance of reasonable standards of hygiene during all stage of the process. A point that should be made clear is that a low total viable bacterial count represents in general an index of reasonable care in manufacture and reduces the occurrence of “souring” and other types of spoilage.

Spoilage microorganisms commonly found in the meat processing environment are bacteria, yeasts and moulds, all of which, together with some physical and chemical factors, can render a meat or sausage inedible and unattractive by destroying the colour, flavour and structure. The growth of microorganisms in meats and in finished sausages is affected by processing temperature, available water and its activity in meat, oxygen, pH-value and the salt and nitrite contents. Most influential are temperature and water. Apart from these factors, the shelf life of sausages is determined by the initial bacterial count of meat and other sausage components.

Temperature.

One easy way to increase sausage shelf life is to lower the temperature of all rooms need in the processing, and storage of meats and sausages. The meats undergoing sausage processing should be processed at such temperatures that bacterial growth cannot occur until the pH and water activity values are sufficiently reduced to inhibit microbial action. Where there is a lack of such conditions, it may be necessary to work at temperatures at which bacterial growth may in theory occur but the processing should be accelerated and a suitable compromise arrived at in which in practice bacterial growth is not found to be significant. In other words, good shelf life and other quality characteristics of finished sausages result from the hygienic conditions present during processing, including hygiene of personnel, methods of processing applied which impede microbiological activity, conditions at which the sausages are subsequently held during storage, transport and sale. If the

minimum conditions are not respected, the sausages are subject to spoilage and deterioration at an earlier storage time than normal. On the contrary, hygienic meat handling and processing markedly extend sausage commercial life.

The required temperature conditions of sausage storage should be fully respected since, if they are unsatisfactory, the precautions taken during processing may be largely nullified by the undue proliferation of the residual flora.

Water activity.

The amount of water needed for growth depends upon many factors — nature of the organisms, available nutrients, etc. When the composition of a sausage product is appropriately formulated, the amount of water required for microbial growth may considerably be reduced and the sausage product shelf life increased.

The state of water in sausages has a direct effect on microbial, chemical and enzymatic reactions. This water activity or the a_W -value, also sometimes expressed as the “free” water content in the sausage, is by definition the quotient of the steam pressure present in the meat and the saturation steam pressure of the pure water under identical temperature conditions (P_S/P_O). The a_W -value of a water-free substance equals 0, that of bidistilled water, 0.1.

The a_W -value of lean meat is about 0.99. In traditional sausage manufacture, a_W is reduced either by drying or by addition of curing salts, nonionic solutes, such as sugar, spices and different additives. It means that the a_W -value can be influenced by appropriate formulation of the sausages as well as by processing methods. Fat, water and salt contents directly influence a_W -value. In sausages where fat and water contents are

substantial and highly variable, it is important to understand fully the role that changes in composition play on the product stability. Thus, the addition of 1 percent level of fat reduces the a_w -value by 0.00045. In the same manner, the addition of 1 percent sodium chloride reduces the a_w -value by about 0.0060 while 1 percent of sugar and 1 percent of soy or milk protein reduce the a_w -value by about 0.0020–0.0025 and 0.0012–0.0013 respectively.

A raw sausage meat mixture containing 30 percent fat, 3 percent salt, 2 percent sugar and 2 percent soy protein has an initial a_w -value of 0.9521. The final a_w -value of the product depends upon the degree of heating and water losses due to evaporation. At a_w -value levels below 0.95 most gramnegative microorganisms are unable to develop and they are gradually replaced by lactobacilli and osmotolerant cocci. At a_w -values lower than 0.88

to 0.90 multiplication of bacteria and yeasts is basically stopped.

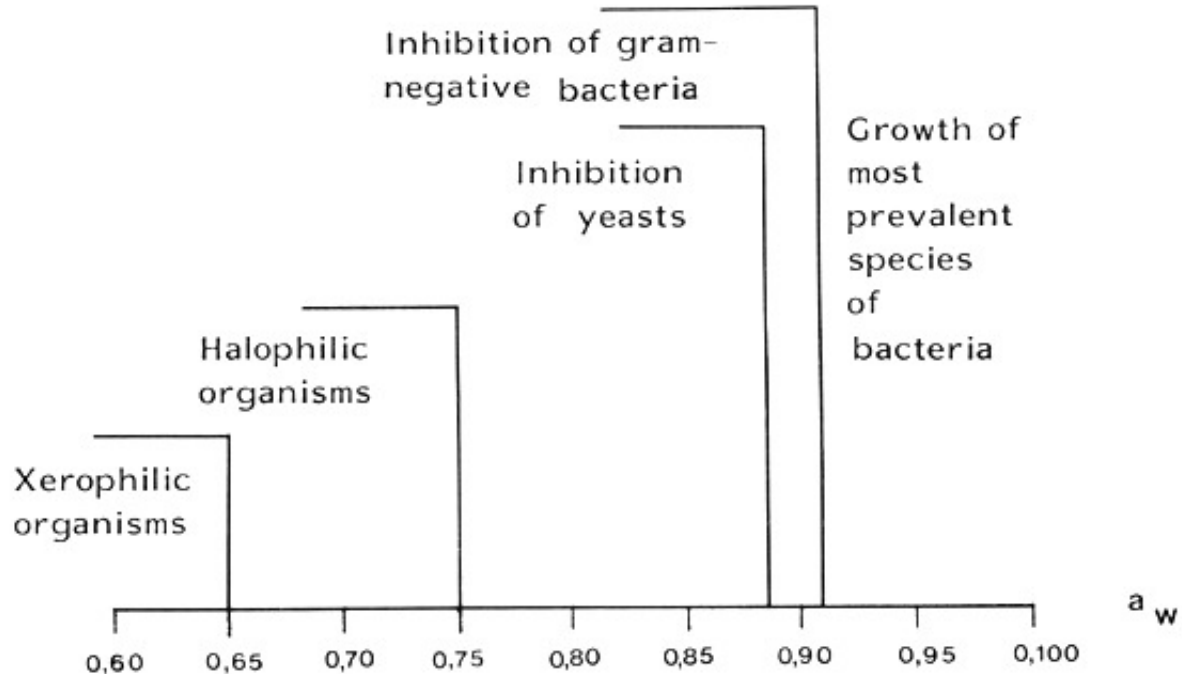


Fig. 39 WATER ACTIVITY VALUES INHIBITING THE GROWTH OF

MICROORGANISMS.

(To inhibit the growth of the most prevalent species of bacteria, the water content of meat must be reduced to a value below 30% and/or the water activity adjusted to below 0.90. Reducing the water content of sausages to prevent spoilage often requires addition of salt to an undesirable level or drying to an excessive extent.)

The reduction to an a_w of 0.92 can be accomplished with no substantial change in product quality. The extent of the a_w reduction required is, however, dependent on a number of processing and storage parameters that differ for different sausage types.

The measurement of a_w is of particular importance to evaluate the preservability of meat raw materials and final sausage products. By measuring in a closed chamber, the relative

humidity is determined, which is in equilibrium with the humidity of the sausage sample. Measuring instruments (a_w -meters) based on electronic technology have been developed which afford the user a rapid and easy a_w determination of meat products.

Control of sausage spoilage and deterioration.

The main forms of sausage spoilage and deterioration are the excessive proliferation of bacteria in the sausage content or on the surface, the excessive growth of moulds on the sausage surface, the oxidative deterioration of sausage fat causing product rancidity, and the excessive dehydration of sausage superficial layers including casings.

The rate at which these four forms of spoilage and deterioration can occur vary widely. For example, processing under unhygienic conditions may cause souring, gas formation, off-

odours, etc. within a few hours after production or the spoilage process can be somewhat delayed and will develop during a longer time period, perhaps in the consumer's home. High storage temperatures and high humidity, poor handling and other adverse conditions may similarly accelerate bacterial and fungal development, especially on the surface of the products. On the contrary, dry air atmosphere, high temperatures and particularly high air circulation rates contribute essentially to development of rancidity and surface dehydration, often accompanied by discoloration and other organoleptic changes.

Surface spoilage, especially of sausage products containing enough moisture, is normally shown either by the appearance of slime, because of excessive bacterial proliferation, or by an abundant generally greyish-white growth of mould. A somewhat lower storage temperature and especially nonexcessive dehydration of the surface may be helpful in this regard and may retard spoilage considerably. If spoilage occurs in the interior of

the sausage, it is usually due to adverse hygienic production conditions as well as to the poor hygienic quality of processed raw materials.

Mould formation on sausage products is generally the result of keeping them in damp, poorly ventilated rooms or of improper packaging. Of the known mould fungi, the *Aspergillus*, *Penicillium* and *Mucor* species are especially apt to establish themselves on sausages, the surface of which they cover first with their white and then grey or greyish-green tufts. It should be noted that these changes are basically of a superficial nature and do not otherwise adversely affect the sausages. Slightly or moderately mouldy sausages are, as a rule, neither injurious to health nor spoiled. After removal of the mould by washing with vinegar or a salt solution they can be passed as food. Only when highly spoiled and with a marked mouldy flavour, the sausage is unfit for consumption.

To ensure maximum spoilage control, the sausages should be held at temperatures as follows:

Table 12 EXPECTED SAUSAGE SHELF LIFE AT VARIOUS TEMPERATURES

Sausages	No refrigeration	10 – 15°C	0 – 4°C	Freezing
fresh	several hours	1 – 2 days	2 – 4 days	about 5 – 7 days; if protected 1 – 3 weeks
semidry	several hours	10 – 15 days	not recommended	
dry	1 – 5 weeks	3 – 6 weeks	not recommended	
smoked, precooked	10 – 15 hours		2 – 4 days (often more)	1 – 3 weeks

emulsion-type	8 – 12 hours	1 – 3 days	3 – 5 days	6 – 10 days
cooked	several hours		2 – 3 days	some varieties may be kept frozen for 2 – 3 weeks

- a. ***Fresh and smoked precooked sausages:*** at 0–4°C for 2–4 days; if frozen, they have to be kept no longer than a week; if no refrigeration is applied, sausages should be consumed within several hours;
- b. ***Emulsion-type sausages:*** at 0–4°C for 3–5 days or at below 10°C for 1–2 days; if frozen they have to be kept no longer than 6–10 days; if sausages are not refrigerated they should be consumed within 8–12 hours;
- c. ***Semidry sausages:*** at below 15°C for 10–15 days; if the sausages are held without refrigeration in a dry ventilated place, their shelf life will be several days;

d. *Dry sausages:* should be kept well protected from air humidity and circulation in a cool dark place.

Discolouration of the sausage surface in the absence of spoilage occurs because of excessive drying, leading to the formation of a peripheric dried dark brown or dark grey ring of coagulated proteins.

Rancidity develops in all sausages but especially in those manufactured from long-stored chilled or frozen meats and fats and usually is associated with excessive air circulation and low air humidity.

DELIVERY OF SAUSAGES TO RETAILERS

The method of sausage transportation from the place of production to place of consumption rather than the processing methods themselves distinguishes sausage making in warm and

temperate climates. The best method of sausage delivery from the plant to the retail shop is by a motor vehicle.

Motor trucks should be especially designed for sausage delivery. The truck body must be sufficiently insulated to prevent the transfer of heat, humidity or dirt from the exterior. The trucks can be refrigerated with ice, dry ice or mechanical equipment.

Dry ice or mechanical equipment is indispensable if transport distances are long. Precautions must be taken to avoid condensation on the sausage surface during loading, transport and unloading. The door of the vehicle can be protected by some type of curtain during loading and unloading to prevent penetration of outside air as far as possible.

Fresh, cooked and small-diameter emulsion-type sausages are transported and kept in specially designed containers. Semidry and dry sausages are hung for sale and storage; the same is

recommended for all large-diameter sausages.

The decision whether to store and transport the sausages in chilled or frozen form or without any refrigeration is of critical importance for sausage manufacturers marketing their own products. The use of refrigeration to transport sausages, if the transport distances are long, has great influence on their keeping life and presentation. However, it should always be kept in mind that there is a definite consumer preference for fresh products, and chilled products are by far preferred over frozen. The products which do not need to be refrigerated should be well protected by suitable methods.

Sale of sausages.

Besides considering market demands over the different seasons, an efficient sausage manufacturer will follow closely day-to-day market fluctuations both of raw materials he is using and his final

product to try to avoid selling his sausages at a time of a temporary fall in prices.

Many sausage manufacturers are able to sell the sausages themselves; some may sell the sausages to retail or wholesale shops. All sellers must acquire specialized knowledge and experience in handling and recommending the product's utilization and serving methods.

Sausage marketing can most efficiently be undertaken by the sausage manufacturer himself. In that case, he will enjoy not only the advantages of his specialization to serve better his customers but will also be able to discuss directly with the consumer any critical points, remarks and preferences regarding his products. Thus the problem of quality control of his sausages will be enormously simplified.

Normally, fresh and cooked sausages should be sold to the

consumer public immediately after production. This practice guarantees the best organoleptic quality and the lowest risk for the consumer, as well as the maximum profitability for the sausage manufacturer. The cold storage of these products should be considered only as an exceptional operation. Smoked precooked sausages must be sold not later than 1–2 days after production, regardless of storage conditions, because they quickly change their organoleptic and other properties. The semidry and dry sausage should also be produced and sold strictly according to market demand.

If intended for longer storage, the sausages should be prepared under highly hygienic conditions, be free from visible spoilage or other defects, properly packaged, if necessary, and should be in a very good general condition. If these conditions are not fulfilled, there is a grave risk that stored sausages will be unsuitable for consumption on reaching the market.



Fig. 40 SAUSAGE RETAIL PACKAGES

(Photo courtesy of Kraemer und Grebe, GmbH & Co KG. D-3650 Biedenkopf-Wallau, W. Germany)

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