PRACTICAL ACTION
Technology challenging poverty

HOW TO MAKE SAUSAGES

FRESH AND FERMENTED

technical brief

Introduction

A wide variety of sausages are produced in countries throughout the world. Most are produced from meat (especially pork and beef) but in some countries, fish sausages are also popular. Vegetarian and vegan sausages are available in some countries, made from tofu, nuts, pulses, mycoprotein, soya protein, vegetables or combinations of these ingredients. Some are shaped, coloured and flavoured to resemble the taste and texture of meat, whereas others have the flavour of the spices and vegetables and do not attempt to imitate meat. Sausage meat is ground, often spiced, meat usually sold without a casing. It may be formed into patties, stuffed into poultry, sold as slices cut from a block of pressed meat and fried, or used for wrapping foods such as Scotch eggs. It is also encased in puff pastry to make sausage rolls. This technical brief focuses on meat sausages.

Sausages are ground seasoned meats, stuffed into casings. They are made from any edible part of a veterinary-inspected animal, together with a variety of non-meat ingredients. Changes to the formulation of ingredients, particle size of the meat, processing methods and processing conditions produce the wide variety of sausages that are found. Different types of sausages may be grouped into fresh and fermented (or 'cured') sausages. Fresh sausages have a relatively short shelf life and must be kept under refrigeration (by chilling or freezing) until they are cooked by the consumer by frying, boiling or baking immediately before consumption. Fermented sausages are made from cured meats that are not heat processed, and they are divided into semidry and dry sausages. The use of curing salts, the increased acidity from the fermentation, plus for some types, additional preservation due to drying and/or smoking, enable these sausages to be stored without refrigeration and they may be consumed without cooking.

Production of fresh sausages

Examples of fresh sausages include braunschweiger, liver sausage, siskonmakkara, cervelat, blood sausage (or 'black pudding'), saveloy, wuerstel, jagdwurst, weißwurst and breakfast sausage. 'Hot dogs' are very finely ground meat paste that may also be smoked or boiled in brine. Precooked sausages such as Kochwurst, Saumagen and Blutwurst are made with cooked meat but may also include raw organ meat. They have a shelf life of a few days at refrigerator temperatures. There are also sausages that are named after the region in which they have been traditionally produced (e.g. Morteau in France, Cumberland and Lincolnshire in UK, morcilla de Ronda in Spain, toruńska (from Toruń) in Poland, and Sremski kulen (after the region of Srem in Serbia). Some of these areas are seeking Protected Designation of Origin for their sausages so that they can only be made in that region to an attested recipe and quality standards. In Latin and South America there are many types of sausages, with slight regional variations of each recipe: for example, morcilla or relleno (blood sausage) and salchichas (similar to hot dogs). In North Africa, Merguez is made with beef flavoured with a wide range of spices, such as paprika, Cayenne pepper, or hot chilli that gives it a red colour. It is stuffed into lamb casings, and grilled or sun-dried and used to add flavour to other dishes. In South Africa, traditional sausages are known as boerewors (farmer's sausage), made from game animals and beef, mixed with pork or lamb and with a high fat content. They can be either fresh or dry-cured.

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Fresh sausages are best produced from warm slaughtered meat, before rigor mortis sets in. This is because pre-rigor meat has a higher water-holding capacity that improves the structure and yield of the sausages. Also pre-rigor meat maintains a red colour in fresh sausages for up to 5 - 6 days of refrigerated storage and several weeks in frozen storage, whereas sausages made from chilled meats can fade to a brown-grey colour during storage. Using pre-rigor meat also gives savings in refrigeration costs.

Formulations for fresh sausages include the meat, added fat, iced water and a variety of seasonings, herbs and spices (Table 1). This variety of ingredients is limited only by a processor's imagination and knowledge, but the formulation is always a compromise between the expected quality of the finished product, the cost of raw materials and the processing techniques that are applied. Common seasonings are salt, dextrose, black or white pepper, mace, sage, chilli, red pepper, garlic, cinnamon, onion powder, cumin, monosodium glutamate or celery salt. Seasoning formulae vary widely depending on particular market preferences, but two common seasoning types are a sweet herb flavour or a hot seasoning. In some countries, breadcrumbs or other binders (e.g. wheat flour and rusk, milk powder or soy protein) and emulsifiers are also permitted to control shrinkage of the sausage during cooking. If binders are used, the amount should not be more than 2-3% of the weight of the meat in a fresh pork sausage formula or 1-2% in a fresh beef sausage formula. Extra dextrose or sugar helps to brown the sausage rapidly during cooking.

Pork	**Beef**
1) Using 9 kg fresh pork trimmings (60-70% lean meat) + 1 kg pork back fat: seasoning = 180 g salt 15 g ground white pepper 10 g mace 20 g sage 10 g sugar or 180 g salt 24 g pepper 11 g sage 15 g ginger 0.2 g chilli 2 g monosodium glutamate	1) Using 8.5-9 kg lean beef or beef trimmings (30% beef may be substituted by mutton) + 1-1.5 kg beef or mutton fat: seasoning = 200 g salt 5 - 10 g red pepper 0.1 - 0.2 g chilli 2 - 6 g cardamom 2 g ginger 1 - 5 g fenugreek 2 - 6 g sugar Rusk may be added to improve binding and 20-30 g salted water may be added to facilitate stuffing
2) Using 6 kg pork belly + 4 kg lean pork: seasoning = 180 g salt 20 g pepper 10 g mace 10 g ginger 4 g cardamom 10 g lemon bark powder 1 g fresh garlic	2) Using 8.5 kg beef flank + 1.5 kg beef fat (brisket fat, fat trimmings or mutton fat) seasoning = 180 g salt 2 - 22 g curry powder 5 g sugar 20 g pepper

Table 1. Examples of formulations for 10 kg of fresh sausages (Adapted from Savic, 1985)

In developing any product, processors should consider these formulations as a basic starting point and spend time to test, modify and adjust them according to local preferences and requirements.

Good quality sausages cannot be made from inferior or unsatisfactory raw materials. Fresh meat and other ingredients (especially spices) may contain bacteria that cause spoilage and/or food poisoning. To minimise their growth, iced water is used to keep the temperature of sausagemeat below around 4°C, and it should be processed as quickly as possible. Also, strict attention is required to hygienic handling, sanitation and cleaning procedures to prevent

bacterial contamination that would reduce the shelf life of the sausages and/or cause a safety hazard. The high risk of food poisoning from fresh sausagemeat is reflected in the legislation in many countries, which may specify maximum levels of food poisoning bacteria, and may also specify the hygiene and sanitation procedures that must be used when preparing sausages. The ratio of lean meat to fat has an important influence on the quality of the product, particularly in controlling shrinkage during cooking. Formulations that have higher proportions of lean to fat show less shrinkage than formulae with more fat. A highly acceptable pork sausage can be produced using a formulation that contains 35% fat. The addition of a small amount of water or milk (3-5%) facilitates stuffing sausagemeat into casings. In many countries, the legislation may also set out specific compositional and labelling requirements, such as minimum meat content for sausages; added water over certain limits; or added ingredients of different animal species that must be declared on the product label.

A meat grinder (Figure 1) forces meat under pressure through a cylinder with sharp-edged ribs and then through a series of holes in a perforated plate. As the compressed meat exits through the plate, a revolving four-bladed knife cuts it. The meat should be thoroughly trimmed of fat and connective tissue, sprinkled with the seasoning mixture and then ground twice: once through a coarse plate (8-12 mm holes) followed by mixing in any binder and a second grinding through a finer plate of 2-4 mm diameter holes.

Figure 1: Meat grinder. Photo: W. Weschenfelder and Sons, www.weschenfelder.co.uk

Manual or motorised meat grinders are used for most types of sausages, but processors who wish to make emulsion-type sausages or those who can afford higher levels of investment use bowl choppers (Figure 1). These machines have a slowly rotating horizontal bowl that moves the ingredients beneath a set of high-speed rotating blades. Coarsely chopped meat and the other ingredients pass several times beneath the blades until it is chopped and blended to the required extent.

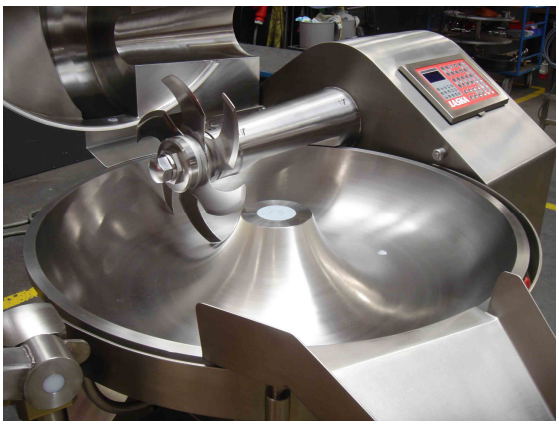

Figure 2: Bowl chopper. Photo: Courtesy of Union Food Machinery Ltd. www.ufm-ltd.co.uk.

Emulsion-type sausages (e.g. 'hot dogs' or frankfurters) are meat emulsions in which tiny fat globules are dispersed in water that contains a complex mixture of meat proteins and gelatine. The structure of the emulsion is set when the sausages are cooked, to produce the characteristic texture of the product. Factors that affect the stability of the meat emulsion, and hence the texture of sausages, include the type and quality of the meat, which affect the water-holding capacity and fat-holding capacity of the meat proteins; the proportions of meat and iced water to fat; and the time, temperature and speed of homogenisation of ingredients in the bowl chopper. Sausage texture is also affected by the use of polyphosphates to bind water into the sausage structure, but these are not routinely used in small-scale production.

After grinding, the sausagemeat is stuffed into casings that have been soaked in clean water or dilute brine. A meat temperature of 2 - 4°C and good fluid properties of the sausagemeat are

required for stuffing fresh sausages. Traditionally, sausage casings were made of cleaned pig or sheep intestines, but they are now also made from collagen, cellulose, or other plastics. Casings of different diameters include: wide (22 - 24 mm), medium (20 - 22 mm), narrow medium (18 - 22 mm) and narrow (16 - 18 mm). Medium sized casings are preferred for pork sausages, especially if they are formed into links, and narrow casings are more suitable for beef sausages. Manual or motorised sausage stuffers (Fig. 3), have a cylinder that contains the sausage meat and a moveable plunger that forces the meat through an outlet pipe (or 'horn') into the sausage casing. The casings are filled to maximum capacity to prevent air becoming trapped, which could discolour the sausages. Linking is carried out by twisting the stuffed casing at regular intervals to give the length of sausage required by the local market. This varies widely but short links of 5 - 7 cm or long links of 10 - 15 cm are common lengths. Linking may be done by hand or using a linking attachment to the sausage stuffer.

a) b)

Figure 3: Sausage forming equipment, a) manual sausage stuffer (SAP at http://sapbologna.it), b) Motorised sausage stuffer (REX-Technologie GmbH & Co. KG at www.rex-technologie.com)

After stuffing and linking, fresh sausages should be chilled rapidly by hanging them in a chiller and they should be kept at refrigeration temperatures of 0 - 4°C to give a storage life of up to 6 days. Good circulation of air in a refrigerated storage room is necessary but if the air circulation is too rapid it will cause excessive drying and shrinkage of the sausages. The correct air humidity is 75 - 80% to prevent excessive loss of moisture and avoid mould growth. Sausages should be kept at refrigeration temperature until they are cooked. This requires a cold distribution chain from the processor to the retailer or food service outlet. In some countries the measures to control the temperature during distribution and sales are controlled by law. Because of the risk from food poisoning bacteria, fresh sausages should be heated sufficiently to destroy any bacteria that are present at the centre of the product. The temperature and time of heating should also be sufficient to produce the required changes to the flavour and colour of the sausages.

Fermented sausages

Fermented sausages are produced using similar methods to fresh sausages but the ground meat is fermented (or cured) either before or after stuffing. The stuffed sausages are then smoked, dried or aged to make a product that can be consumed without further cooking. Unlike fresh sausages, the long shelf life of fermented sausages is due to their low moisture content (low water activity), acids produced during the fermentation, and smoke compounds if the sausages are smoked. These preservation factors prevent the growth of pathogens and spoilage micro-organisms and allow the sausages to be stored at room temperature and eaten without cooking.

The ingredients used in fermented sausages include coarsely or finely chopped meats, fat, lactic acid bacterial starter culture, spices, sugar, salt and curing salts (sodium or potassium nitrite and/or nitrate). Meat used for fermented sausages should be carefully trimmed to remove sinews and soft inter-muscular fat. Methods of grinding and chopping depend on whether the sausage is intended for slicing or spreading: in general, finer grinding produces improved spreading properties. Beef is normally chopped first and then the pork and other ingredients are added. Salt and curing salts are added at the end of chopping. The sugar is added to speed up the growth of lactic acid bacteria and curing salts are used to prevent the

growth of food poisoning bacteria, especially *Clostridium botulinum* and production of the toxin 'botulin', before the meat is acidified by the lactic acid bacteria and because these products may be consumed without cooking. Examples of meat formulations for fermented sausages are shown in Table 2.

Sausage	Beef (%)	Pork (%)	Pork fat (%)	Spices
Large diameter salami:				
German type		65–75	25–35	Coriander, garlic
Italian type	30	45	25	Ginger, garlic
Hungarian type		70	30	Chilli pepper, nutmeg, cardamom, garlic
Polish type	10–15	55–60	25–30	Marjoram
Small diameter:				
Salametti	30	40	30	
Garlic sausage	50	20	30	Chilli pepper, rosemary, garlic
Beef garlic sausage	80	-	20 (beef fat)	Fenugreek, chilli pepper, ginger, garlic

a)

Ingredients for 10 kg of fermented sausage	
Summer sausages 5.5 kg lean beef 2.5 kg pork bellies 2.0 kg pork fat 300 g sodium or potassium nitrite salt 5 g sodium nitrate 30 g ground black pepper 12 g coriander 20 g mustard seed 4 g garlic 4 g allspice 55 g dextrose 25 g sucrose	**Chorizos** 3.3 kg lean pork or lean beef 3.3 kg pork neck or beef flank 3.4 kg fat pork (jowl, belly, fat trimmings) or beef trimmings 280 g sodium or potassium nitrite salt 4 g potassium nitrate 8 g sugar 10 g garlic 20 g red pepper 15 g chilli
Pepperoni 5.0 kg pork trimmings 3.0 kg beef chucks, hearts, cheeks 2.0 kg pork jowl 280 g sodium or potassium nitrite 5 g sodium or potassium nitrate 5 g chilli powder 2.0 g allspice 15 g fenugreek 30 g ground pepper 45 g red pepper 15 g anise 100 g sugar 3 g peeled garlic 25 g dextrose	**Beef salamis** 7.5 kg beef chucks or other beef 2.5 kg beef brisket fat 250 g sodium or potassium nitrite salt 4 g potassium nitrate 5 g fresh garlic 25 g ground white pepper 20 g dextrose 10 g red pepper 2 g ginger

b)

Table 2. a) Formulations of fermented sausages and b) typical ingredients for four types of fermented sausage. (Adapted from Savic, 1985).

The chopped meat mass should be well mixed and then either stuffed into casings or placed in shallow pans and held under refrigeration to enable the fermentation to take place. Any air pockets under the casings would discolour the meat and allow the growth of spoilage micro-organisms or pathogens before the pH falls. Casings are therefore punctured to allow any air to escape. Similarly, in pans, the meat mixture must be kneaded to remove air pockets and covered to prevent contact with air. After fermenting in pans, the sausage meat is remixed and stuffed into casings as firmly as possible and the stuffed casings are tied or clipped, with a loop to suspend the sausages during further processing.

The two types of fermented sausage are semidry (or quickly fermented) and dry (or slowly fermented) sausages. In both groups there are hard types that can be cut into thin slices and spreadable soft types.

Dry fermented sausages

Dry sausages have a long shelf life without refrigeration because of their high salt (more than 4%) and low moisture contents (25 - 35% water). Their water activity (a_w) = 0.85 - 0.91, which prevents the growth of bacteria and most moulds. Dry sausages made from salted, spiced pork and/or beef sausages are found in the warmer climates of Mediterranean countries. The main types are pepperoni, different types of salami, cervelats and many small-diameter dry sausages. Dry sausages are usually sold as 'new' (about 20% weight loss from original weight), 'moderately dry' (about 30% weight loss) or 'dry' sausages (about 40% weight loss). The properties of the final product depend on the formulation, degree of grinding of the meat, fermentation time, temperature and time of drying (or 'ageing'), the type and size of the casing, and for some the intensity of smoking. They are made from either coarsely chopped meat (e.g. Italian salamis, some types of sucuk); moderately chopped meat (most small-diameter sausages); or occasionally finely chopped meat. Spices contribute mostly to the flavour of dry sausages but they also inhibit spoilage bacteria, while stimulating the growth and acid production by some lactic acid bacteria. In traditional processes, fermentation is by naturally occurring bacteria, and to achieve a safe product it is important to optimise the growth conditions for the bacteria. This involves adding sugar to promote growth, controlling the temperature, and adding curing salts to inhibit the growth of spoilage or pathogenic bacteria. The raw sausage mixture, containing meat, fat, curing salts and sugar, is placed in 15 -18 cm deep pans and kept for 2 - 4 days at 3 - 4°C. A shorter fermentation time, within 24 hours, can be achieved at a higher incubation temperature (35 - 41°C). Lactic acid bacteria use added sugars to produce lactic acid, which causes the pH to fall. A low pH (below 5.2) is very important for the correct preservation of sausages and the development of desirable taste and texture. It is also required to adequately bind the meat and for colour development in the sausage. A pH value below 4.8 influences the taste and extends the shelf life, but it does not contribute to better binding properties of the final product than that achieved at pH 5.2.

Alternatively, a starter culture of lactic acid bacteria produces consistent and controlled acidification that inhibits growth of undesirable micro-organisms and a uniform texture and colour in the final product. Starter cultures are mainly *Lactobacillus, Pediococcus, Leuconostoc* and *Streptococcus* species. Spanish mixed-culture preparations also include *micrococus* sp. The starter culture and seasoning ingredients are added to the chopped meat and mixed in thoroughly. The speed at which the pH falls, and hence the fermentation time, depends partly on the type and amount of sugar that is used: in general, 0.3-2.0% sugar (sucrose) is used, but dextrose is fermented more quickly and cause rapid acidification, whereas lactose or corn syrup are only fermented by some types of bacteria (or more slowly) and the speed of acidification is reduced. If dextrose is used, the amount of added sugar is lower, whereas corn syrup must be added at higher levels to compensate for the slower acidification.

If the mixture is not cured in pans but stuffed directly into casings, the sausages are held for about 10 days at 3°C before hanging them at 22 - 24°C with a relative humidity of 80% for 48 hours. Natural casings are preferred for dry sausages because they adhere closely to the sausages as they shrink during drying or smoking, whereas plastic casings do not. Sausages

stuffed in casings with a diameter exceeding 4.5 cm are often termed 'salamis'; but actual salamis are made from coarsely-ground meat and are not smoked. Most types of dry sausages are cold smoked (12 - 18°C) and in some countries they are heavily spiced with red pepper or garlic or sometimes hot- smoked and strongly salted (see Technical Brief: Smoked Foods) before a long period of air-drying. Sausages that are not smoked are known as air-dried sausages. They have a shrivelled appearance with or without surface mould growth and a yeasty-cheesy flavour.

Sausage drying rooms should have a fan, and facilities for control of the air temperature and humidity. The stuffed sausages are hung in a room at 20 - 23°C with an initially high air humidity (≈98%). In the following 2 - 4 days the humidity must be gradually reduced to below 75 - 80% to remove the surface moisture. They must not dry too fast or the surface will become hardened and a crust develops under the casing. This prevents moisture loss and the sausage has an excessively moist centre and the crust will not allow smoke to penetrate. Neither should they dry too slowly as the surface will become slimy (some producers allow a white covering of moulds and yeasts on the outside of the cured sausage during drying, which adds to the flavour). If it is wished to avoid mould growth, the smoked sausages can be rinsed in hot saturated brine before drying. As a guide, the air humidity should be approximately 4% lower than the water activity of the product (e.g. if the water activity of the product is 0.96, the optimum air relative humidity should be about 92%). The properties of dry sausages depend on both the bacterial fermentation and the changes that take place during a long drying or ageing process: the total process may require up to 90 days. The final pH of dry sausages is usually higher than semidry sausages (5.0 - 5.5).

Semidry fermented sausages

Semidry sausages differ from dry sausages by their 'tangy' flavour produced by lactic acid accumulation from the fermentation. They are usually stuffed into medium- and large-diameter natural or synthetic casings. Their production time rarely exceeds a few days. The pH of semidry sausages is between 4.8 and 5.2–5.4 and their moisture content is 35 - 50% (a_w = 0.90 - 0.94). Semidry sausages are often warm-smoked at temperatures not exceeding 45°C, or occasionally rising to nearly 60°C for a limited time. After smoking the sausages are usually air-dried for a short time in a drying chamber with a relative humidity at 3 - 5% below the moisture content of the sausage. The bacteria and acid, together with enzymes released from the minced meat, contribute to the flavour and colour development and cause the meat pieces to soften and bind together in the sausage. Preservation is due to a number of factors: the antimicrobial action of the salt; up to 2% lactic acid from the fermentation; reduced moisture content; nitrite-spice mixtures; and antimicrobial components in smoke when the product is smoked. Examples of semidry sausages are summer sausages, landjaegar, different types of cervelats, thuringer, metwursts and Lebanon bologna. For example, landjaegers (or hunter's sausages) are flattened semi-dry sausages, made by stuffing a mixture of coarsely ground beef, pork and seasonings into pig or sheep casings. They are pressed using wooden moulds for 1-2 days at about 20 - 24°C, or 2 - 3 days at 18 - 20°C, which gives sufficient time for the fermentation to take place and to obtain the required flat shape. The shaped sausages are removed from the moulds, hung from rods and smoked for 3 - 4 days at 16 - 20°C.

Figure 4: Sausages being cured.
Photo: courtesy of Wikimedia commons at http://en.wikipedia.org/wiki/File:Saucisson_04.JPG)

technical brief

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