NON-MEAT INGREDIENTS

Categories of non-meat ingredients

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

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

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

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

Additives (Fig. 87 right) are usually substances, which are not normally consumed as food by itself, but which are added to develop certain technological and quality characteristics (for examples salt, curing agents, spices, water binding and gelation enhancing substances). In contrast, vegetables, flours, eggs, etc. (Fig. 87 left) could be considered as full food ingredients.
Most ingredients are functional, which describes their ability to introduce or improve certain quality characteristics. The functional properties of ingredients include their impact on:

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

Ingredients which are solely functional without any other effect such as filling or extending the volume of the product, are normally used in small amounts (e.g. common salt 1.5-3%, nitrite 0.01-0.02%, phosphates 0.05-0.5%, ascorbic acid 0.03%, isolated soy protein or non-fat dried milk proteins 2%) (Fig. 88, 89 right).

The criteria for the utilization of functional non-meat ingredients are:
- safe for consumers, and
- improve of processing technology and/or sensory quality of the products.

Fig. 88: Example of effect of functional ingredients
Meat loaf cut, left with curing colour, centre without colour, right with artificial colour
In contrast to the exclusively functional substances, there is another group of ingredients that are not primarily intended for change of appearance or quality improvements but serve to add volume to the meat products. They are called **meat extenders** and **fillers**. Their main purpose is to make meat products lower-cost. Meat extenders and fillers include cereals, legumes, vegetable, roots and tubers and are used in larger quantities, on average between 2 and 15% (Fig. 89 left and center).

**Meat extenders** are primarily plant **proteins** from legumes, with **soybeans** as the major source. **TVP** (Textured Vegetable Protein, see page 80) is the most common soy bean extender. These cheaper plant proteins “extend” the more expensive meat proteins, resulting in acceptable overall protein contents of lower cost meat products. Extenders are added in sizeable amounts that increase the bulk of the meat products, but this may also alter their quality. From animal protein sources, whole milk and eggs can be considered as meat extenders. In some countries, replacement of meat by fish is gaining popularity resulting in fish products which may be meat and fish mixes or entirely made of fish materials, e.g. “fish viennas”, made using the same technology and process as viennas made of meat (Fig. 90).
**Fillers** are also mostly plant substances, low in protein and high in **carbohydrates** such as cereals, roots, tubers and vegetables and some refined products such as **starches** and **flours**. Pure meat products are very low in carbohydrates. Hence the addition of carbohydrate-rich substances is not an “extension” of the protein mix, but some new components “fill-up” the product volume. Apart from their volume-filling capacity, some fillers, in particular starches and flours, are also used for their capability to absorb extensive quantities of water.

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

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

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

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

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

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

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

b) Non-meat ingredients of animal origin

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

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

C) Ingredients of plant origin

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

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

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

and, less importantly, protein isolates from other legumes.

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

**Meat extenders / Plant products with high protein content are**

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

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

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

**Application of non-meat ingredients**

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

**Methods of application**

a) During grinding

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

b) During chopping

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

c) Application to non-comminuted meat

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

**Treatment before application**

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

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

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

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

**Fig. 94**: Application by surface treatment / dry salting
Important non-meat ingredients in meat processing and their properties

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

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

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

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

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

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

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

**Sodium Nitrite**
Levels used: 0.01 – 0.03%
The addition of relatively small quantities of sodium nitrite produces the development of the desired colour “pickling red” in processed meat products. Without nitrite meat products turn grey in colour when heated. Of special importance for canned meat products is the potential of nitrite to inhibit microbial growth. Furthermore, it retards the oxidative rancidity by stabilizing fats. The common commercial form of nitrite is **“nitrite curing salt”** or “pickling salt”, a mixture of 0.5 - 0.6% nitrite and 99.4 - 99.5% sodium chloride (see also page 34).

**Ascorbic acid, sodium ascorbate, erythorbate**
Level used: 0.03%
Ascorbic acid is perhaps better known as vitamin C. Its more stable salt form is sodium ascorbate or the chemically equivalent but cheaper sodium erythorbate. These so-called **“cure accelerators”** are used in curing-salt for processed meats because of their reducing properties. These substances accelerate the reaction of nitrite with the red muscle pigments resulting in the development of the red curing colour. Meat products to be heat-treated during manufacture instantly develop a uniform red colour, which can be intensified in the presence of cure accelerators. Similar reactions take place in non-heat-treated products such as raw-cured hams or sausages, but are considerably slower. Another effect of cure accelerators is that the chemical curing reactions will be more complete and hence less residual nitrite will be left in the product (for more details see page 37, 134, 137, 179).
Phosphates
Levels used: 0.05 – 0.5%
Phosphates have a wide application in the meat processing industry and improve binding and texture in processed meat products. They directly increase the water-holding capacity by raising the pH as their own pH is alkaline (above 7.0). Phosphates also stabilize the texture of meat products by increasing protein solubility in connection with salt and reduce lipid oxidation/rancidity and hence the occurrence of negative flavours. Phosphates have also shown the ability to reduce microbial growth. The most common phosphates used in meat processing are:

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

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

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

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

**Gelatine**

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

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

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

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

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

**Carrageenan**

Carrageenan is a hydrocolloid (often known as “gum”) derived from aquatic plants (seaweed). Carrageenan is available as a refined powder (Fig. 99), which is water soluble and has strong **water-binding and gelling** properties. Upon cooling it forms an elastic gel which remains stable during refrigerated storage. Carrageenan, needed only in small quantities of up to 1% and added as a dry powder, can provide improved cooking yield and better sliceability and cohesiveness. It not only
Non-meat ingredients increases the water retention in cooked hams or raw-cooked products, but also contributes to a desired stability and juiciness in products with reduced fat content (such as corned beef in jelly).

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

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

Levels used: 0.5 - 4.0 %

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

**Flavour enhancer**

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

**Food colourings**

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

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

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\(^1\) Sugar obtained from sugar cane or sugar beet

\(^2\) Sugar obtained by hydrolysis of starch, source of energy in living organisms
Food colourings may be derived from **natural sources** (e.g. orange-yellow beta-carotene from green plants, red oleoresin from paprika, red colour from red beet juice). Others are made **synthetically** (also beta-carotene derives now mainly from synthetic sources). Many of them are restricted for use only in particular food products. The debate over the safety of some substances, in particular the synthetic ones, is ongoing.

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

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

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

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**Preservatives**

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

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

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

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

\(^{1) – 6)\) See box page 76
Thanks to growing consumer awareness also in countries with less stringent sanitary controls, hazardous methods to extend the shelf-life of fresh and processed meat are gradually being phased out. By taking advantage of the highly sensitive analytical methods nowadays available, such illegal practices can be completely eliminated by official **sanitary control measures**.

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**Malpractices in meat preservation**

- **Formalin or Formaldehyde** is a strong disinfectant (see page 372); if illegally used to control bacterial growth on meat surfaces, it may get into the food chain, may cause kidney damage and is carcinogenic in the long term.

- **Borax** = Sodiumtetraborate, an ingredient in washing powders and used in paper and leather manufacture; is harmful by ingestion if illegally used for meat surface treatment or in meat mixes.

- **Chlorine** (Cl₂) is an effective disinfectant e.g. for drinking water (0.4-0.6 ppm), also sometimes used for microbial control of water for spin chillers in poultry slaughter (up to 20 ppm). “Bleach” which is calcium hypochlorite (CaOCl₂), reacts with water and releases chlorine ions, which may affect taste and create harmful residues.

- **Hydrogen peroxide** (H₂O₂), when applied to meat surfaces etc. it disintegrates into oxygen and water, whereby the oxygen develops the antimicrobial and bleaching effect. It causes colour changes on meat surfaces, sometimes used for bleaching cattle stomachs (tripes). Another substance used for bleaching tripes is Calcium carbonate (CaCO₃).

- **Antibiotics** such as nisin (= bacteriocin deriving from Strept. lactis bacteria), suppresses bacterial growth, used for some foods (dairy industries), but generally not allowed and discouraged for use in meat industries; or sulphamethazine used as an antibiotic in pigs with possible residues occurring in the meat.

- **Sulphur dioxide**, is widely legally used in food manufacturing (fruits, juices), but use in the meat sector discouraged or forbidden, as it would further add to the daily intake by consumers and, most importantly, it may make poor quality products open to adulteration. The substance has a notable effect on raw red meat, in particular on the hygienically very sensitive minced meat, as it can reverse dark brownish colours of over-stored products causing them to lighten and reddening in colour. Moreover, also the beginning bacterial spoilage can be masked through the substance’s inhibitory effect on microorganisms.

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

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

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

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

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

Cereals, Legumes, Roots, Tubers and Vegetables

General

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

Cereals

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

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

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

Fig. 103: Rice sausage
Food Legumes
The most important examples of this group are beans, peas, lentils, cow-peas and chick-peas. **Whole seeds** are used only for certain indigenous products. Care must be taken that the legumes are free of impurities (dirt, sand, insects etc). They are usually soaked in salted water for 1 to 2 hours prior to processing. Products with whole seeds should undergo immediate heat treatment at the processors level in order to avoid possible product spoilage caused by enzymatic reactions if stored without heat treatment.

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

**Soy grits** (pressed dehulled and de-oiled soy beans) or **soy flour**, finely ground, contain 50 percent protein. It is used in meat loaves and minced meat products to add protein and help hold the meat juices. Its main limitation is taste (“beany”) and texture of the final product. Amounts to be added vary, but should not exceed 5% (dry).
**Soy concentrate**, contains about 70 percent protein. It may be used in flour or granular form for finely comminuted meat products. If its structure is changed to granular form to duplicate the texture of ground meat, it is called *textured vegetable protein (TVP)* (Fig. 104, 105, 107). Soy concentrates are almost neutral in taste and cause much less “beany” flavour in processed meats than soy flour. Amounts to be added to heavily extended products may be as high as 15% (dry) for hamburger type goods and up to 6% (dry) for raw-cooked goods. Before processing, re-hydration at a ratio of 1:3 is needed.

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

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

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

**Fig. 109: Production steps for soy protein emulsion**

1. Composition of protein emulsion (water, vegetable oil, soy isolate)
2. Final protein emulsion
Non-meat ingredients

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

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

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

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

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

Gari – The cassava mash (low in protein, high in fibres) remaining from cassava starch production can be stir-fried until granules are formed. This product can now be stored in a dry and cool place and is a good and low-cost extender for all types of cooked meals and fresh sausages (Fig. 111).
Sweet potato, Irish potato will be added mainly fresh and peeled. The preparation is similar to the one for fresh cassava. Potatoes are an ideal supplement to cassava as fillers for simple meat preparation as the taste of the final product is refined. Fresh and peeled potatoes can be stored refrigerated for 2 to 4 days if kept in fresh, slightly salted water.

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

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

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

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

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

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

**Natural spices**

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

**Herbs**

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

**Vegetable bulbs**

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

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Fig. 113: Origin of natural spices
Extracts
Natural spices are often contaminated with high numbers of microorganisms, in particular spores, due to their production process. This may become a problem for the stability of the meat products. The microbial load of spices can be reduced by irradiation or fumigation. Such treatments are not allowed everywhere. Another option is the use of spices extracts. Extracts are produced by separating the flavour-intensive fractions through physico-chemical procedures (e.g. steam distillation) which results in germ-free flavouring substances. Extracts are preferably used in viscous liquid or oily form. Due to the absence of microorganisms, extracts are specifically recommended for the production of microbiologically sensitive processed meat products, such as cured-cooked hams or cured-cooked beef cuts.

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

- Spices (whole or ground, natural or extractives) should always be kept in a cool, dark and dry place.
- They must be stored in tightly sealed containers or bags to avoid loss of flavour.
- For processing purposes, spices should only be removed from the storage container using a spice spoon. Under no circumstances should spices be removed by hand as the adhering moisture and germs will lead to contamination, loss of flavour and clotting of the dry mixes.
- For all production, spices should be added by exact weight in order to standardize flavour and taste of the product.
- Products, which are consumed hot should be spiced mildly, as in the hot product higher amount of flavouring agents (oleoresins, aqua-resins and essential oils) will be released.
- If spices are added to a product mix under high temperature, the seasoning should be strong. In case of cold consumption of this product less spice will be released and taste and flavour will be weak if there is not enough seasoning.
Table 3: Common Seasonings used in processed meats

<table>
<thead>
<tr>
<th>Description and origin</th>
<th>Uses (in gram per 1 kilo of product)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. SPICES</strong></td>
<td></td>
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<tr>
<td>Black/white pepper</td>
<td>Used in a variety (almost all) meat products 1–2.5 g / 1 kg.</td>
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<tr>
<td>Fruits seed</td>
<td></td>
</tr>
<tr>
<td>Paprika (Fruit seed)</td>
<td>Used in frankfurters, minced specialties and other products. Sometimes used as a colouring agent. 1-5 g / 1 kg.</td>
</tr>
<tr>
<td>Chilli (Fruit seed)</td>
<td>For spicy products</td>
</tr>
<tr>
<td>Pimento (Fruit seed)</td>
<td>It has an aroma similar to a mixture of nutmeg, cinnamon and cloves. Used in a variety of sausage products. Sometimes used as a partial replacement for black pepper in frankfurters and some smoked products. 0.3-3.0 g / kg</td>
</tr>
<tr>
<td>Mace (Flower)</td>
<td>Used in liver sausages, frankfurters and bologna and similar. 0.4-1.0 g / kg</td>
</tr>
<tr>
<td>Ginger (Rhizome) (Root)</td>
<td>Used in frankfurters and similar products. 0.3-0.5 g / kg</td>
</tr>
<tr>
<td>Nutmeg (Fruit seed)</td>
<td>Used in bologna and minced ham sausages, frankfurters, liver sausage and gelatinous meat mixes. 0.3-1.0 g / kg</td>
</tr>
<tr>
<td>Clove (Flower)</td>
<td>Used in bologna, gelatinous meat mixes and in blood and liver sausage. 0.3-0.5 g / kg</td>
</tr>
<tr>
<td>Cinnamon (Bark)</td>
<td>Astringent and sweet, used in some countries in mortadella and bologna sausage. 0.1-0.2 g / kg</td>
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<tr>
<td><strong>B. AROMATIC SEEDS</strong></td>
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<tr>
<td>Cardamom</td>
<td>Rapid loss of aromatic constituents during storage. Used in liver sausage and gelatinous meat mixes. 0.3-5.0 g / kg</td>
</tr>
<tr>
<td>Celery seed</td>
<td>Used in fresh pork sausages. 0.3-2.0 g / kg</td>
</tr>
<tr>
<td>Coriander seed</td>
<td>Contains about 13% of fatty matter and a trace of tannin. It is used in frankfurters, minced ham, luncheon meat. 0.3-1.0 g / kg</td>
</tr>
<tr>
<td>Cumin</td>
<td>Used for meat specialties with distinct flavour. 0.2-0.3 g / kg</td>
</tr>
<tr>
<td><strong>C. CONDIMENTAL HERBS</strong></td>
<td></td>
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<tr>
<td>Marjoram</td>
<td>Used in liver and white raw-cooked sausages and gelatinous meat mixes. 0.5-2.0 g / kg</td>
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<tr>
<td>Thyme</td>
<td></td>
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<tr>
<td><strong>D. CONDIMENTAL VEGETAB.</strong></td>
<td></td>
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<tr>
<td>Onion (Bulb)</td>
<td>Used in liver sausage, gelatinous meat mixes, meat loaves. Sometimes replace garlic. 2.0-10.0 g / kg</td>
</tr>
<tr>
<td>Garlic (Bulb)</td>
<td>Used in many types of raw-cooked sausages. 0.1-0.2 g /kg</td>
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</tbody>
</table>
Fig. 114: Selected seasonings used in meat processing

- White, black and green peppercorns
- Ground coriander and coriander seeds
- Ground and whole nutmeg
- Ground mace and allspice berries
- Cinnamon stick, quills and ground
- Cayenne pepper
- Whole and ground cloves