Preserving and Processing of Livestock Products

Storage and Preservation of Meats

The storage and preservation of meats are achieved through three (3) main methods; **Temperature Controll**, **Moisture Controll** and **Direct Microbial Inhibition.**

Methods:

1. Temperature Control [Chapter 7]

- 1.1 Refrigeration
  - 1.1.1 Storage above freezing point
    - 1.1.1.1 Fresh and Chilled Meats
    - 1.1.1.2 Pre-packaging and Storage Changes
  - 1.1.2 Storage below freezing point
    - 1.1.2.1 Fresh and Chilled Meats
    - 1.1.2.2 Pre-packaging and Storage Changes
- 1.2 Thermal Processing
  - 1.2.1 Pasteurization
  - 1.2.2 Sterilization

2. Moisture Control [Chapter 8]

- 2.1. Dehydration
- 2.2. Freeze Dehydration
- 2.3. Curing

3. Direct Microbial Inhibition [Chapter 9]

- 3.1. Ionizing Radiation
- 3.2. Antibiotics
- 3.3. Chemical Preservatives

Storage and Preservation of Meats
Reference: Lawrie (1985)

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Practical Methods of Meat Preservation

Smoke and Smoking

Smoking of meat is a very old method of preserving meat. The drying and smoking of meats was known to the Egyptians as well as to the ancient Sumerian civilization which preceded them. The advantage of this type of preservation lay in the fact that the smoke overcame objectionable flavors that developed if the drying did not proceed at a rapid rate.

Smoking is defined in Wheaton and Lawson, 1985 as a preservation process combining drying and the deposition of the chemical constituents produced by the thermal decomposition of organic material, usually wood. Part of the bacterial action of smoke is due in part to formaldehyde and phenolic compounds (from the celluloses and hemicelluloses which decompose at a lower temperature than lignin) which accumulate on the surface of the meat. This along with the surface drying prevents microbial growth.

The flavor imparted by smoking varies according to the conditions used to produce the smoke. Moreover, the same smoke will produce different aromas with different meats. To some extent therefore, the flavor of the smoked product depends on the reaction between the components of the smoke and the functional groups of the meat protein.

TYPES

These can be classified basically as: smoked fish and smoked meat. Meats which can be smoked include: beef, pork, poultry, venison (deer), rabbit, goat, lamb and even bear meat. The lean beef, venison, moose antelope, caribou, elk and bear meats are smoked to produce a product called **JERKY**. Jerky can be kept without refrigeration. It can be eaten uncooked or cut into paper-thin slices and creamed. Another smoked product is **BEEF TONGUES**.

In the case of fish, Salmon and Trout are two commonly used species. In the Caribbean, we are very familiar with Smoked Herring.

Animal and fish parts can also be smoked, to produce for example, Smoked Liver and Smoked Roe (fish eggs).

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PREPARATION AND SMOKING

A number of steps have been outlined by Whelan (1988), for the preparation and smoking of fish. Many of them can also be used for meat, and are:

(a) FILLETING

This is important as it exposes the fish flesh to the salt and smoke, and allows for faster drying. It also enables further processing after the smoking process, e.g. canning.

(b) CUTTING

When smoking fish that is cut into small pieces, one obtains an attractive covering (pellicle), which is more attractive, and provides a better protected product for subsequent freezing.

(c) SALTING

This process (i) flavors the fish; (ii) releases moisture from the fish to help to dry it; (iii) modifies the fish flesh - moderate salting improves the eating texture of the flesh, whilst prolonged salting hardens the flesh so it can be sliced for serving. It is advised that only pickling salt be used here, since it is the purest known form that reduces the possibility of contamination.

(d) CURING

This is where the fish is drying out and the salt is equilibrating (like that which occurs in ham making). As well the flavor is developing. In some cases salmon is cured for 24 hours.

(e) SMOKING

May be carried out using any one of four basic techniques: **(1) cold smoking; (2) hot smoking; (3) liquid smoking;** and (4) **electrostatic smoking.**

For fish, cold and hot smoking can be done to impart a difference in texture and color. In the first case, the natural color is retained and/or intensified, and can be sliced like ham. In the latter case, the color is faded and it crumbles on slicing.

Cold smoking

This is done at temperatures below, 30 ^{o}C resulting in an uncooked product which must be secured as would a fresh perishable product.

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Hot smoking
This is done at temperatures usually between 70-80 ^{o}C. These products are therefore cooked and do not need to be further processed unless heavily salted. For hot smoking of fish, the flesh can be "placed on a circular wire-mesh netting (4-mesh) or on small-sized circular trays made of bamboo and the lowered in a tank for steam cooking. It is then drained, spread on trays of 4-mesh-wire-netting and subjected to hot smoking for 3-4 hours until an attractive golden yellow color is imparted to it." (Moorjani, 1984).

Liquid smoking
Liquid smoke is a liquid that has been used to absorb smoke and then concentrated. The product is dipped in this liquid to provide flavor and/or color to it, more easily achieving a uniform smoked flavor.

Electrostatic smoking
This is a process where the smoke particles are positively charged with a high voltage field, whilst the product is negatively charged. "The positive smoke particles are attracted to and deposited on the product surface" (Hamm and Rust, 1947). Like liquid smoking it is a more rapid method of smoking than the conventional way.

There are old-fashioned natural draft smokers which have limitations for cold smoking if the environment is warm (like in the tropics). Modern smokers are forced draft and air conditioned, and therefore useful in any weather.

(f) FINAL PRESERVATION

This is very important since all smoked fish (except Indian smoked fish), keeps very litter than fresh fish. It is necessary to promptly refrigerate, freeze or can the smoked fish promptly.

SMOKING OF MEAT

The simplest and oldest method of smoking meat consists of hanging strips of meat in a loosely woven basket above an open fire to be used as needed. Because the strips are continuously being resmoked, there is no danger of them spoiling.

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In large meat-packing plants, smoking is done in several-storey smoke houses where meat is hung on a shaft which rotates, pushing the meat up and down, thus achieving a uniform smoke. Heat is supplied by heat coil, and sawdust blended from different hard woods and burned over a gas burner, is used to produce the smoke which is drawn in by suction fans.

The meat used, should be of good quality, dry, and boneless. It is cut in flat thin slices **along NOT across the muscle**. IT is then suspended from racks so that no two pieces touch. Hardwoods give the best results, but these should be tried out as some impart a bitter taste or a dark color. Maize cobs make an excellent fuel.

During the first stages of the process, more smoke and less heat should be applied. Gradually the heat (60^oC) is increased so that the meat is not only smoked, but partially cooked. Towards the end, the temperature is gradually reduced (to 40 ^oC and more smoke applied. The treatment is considered finished when, on cutting, it is found that the inside is dry and of a uniform color. the whole process takes up to 30 hours or more. The smoked meat should be allowed to cool slowly, and stored in a dry, preferably dark room.

QUALITY AND GRADING

Certain factors need to be considered when deciding on the quality of the final product. These include: (a) the raw product; (b) the smoking temperature; (c) color formation; (d) flavor; (e) nutritive effects; and (f) texture.

(a) using inferior or stale products generally results in a low quality product. As such, it is always recommended that fresh or frozen raw materials be smoked.

(b) the higher the temperature the faster the product would dry and the less smoke and therefore flavor would be developed.

(c) the consumer demand is for a deep smoke-colored product with only a light- smoked flavor.

(d) this depends on the presence of sufficient product moisture to capture the necessary flavor compounds from smoke. The lower the

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temperature used for smoking, the greater the flavor and odor development as drying is slower.

(e) smoke is known to destroy some of the thiamin and decreases the available lysine, whilst having negligible effects on niacin and riboflavin of the smoked product.

(f) changes here are due to both chemical reactions between smoke and the product, from the extent and rate of drying and salt content to name a few variables. In most cases, protein coagulation results in a generally firmer textured product.

Grading of the product would depend on the final quality obtained.

MARKETING

Despite its smoked nature, unless salted smoked fish is still a perishable product. Packaging is therefore important to improve shelf-life of the product. The materials used should provide moisture, mechanical and external odor protection, and be greaseproof. Some products like Smoked Herring are sold 'loose' in the Caribbean. Smoked products should be refrigerated or frozen without being in direct contact with ice however.

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Salting and Pickling of Meats

Activity: Reading

Please Read **: Preservation of Fish and Meat, by Brigitte Maas-van Berkel, Brigiet van den Bogaard and Corlien Heijnen (1996), AGRODOK 12, CTA,** which describes a wide variety of simple meat preservation techniques. Read Chapter 3 Salting Fish and Meats.

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Meat Chemistry

Meat Colour

Meat color is the important first impression consumers have of any meat product. The color of meat may range from deep purplish-red of freshly cut beef to light gray of faded cured pork.

Myoglobin is the muscle pigment which changes to give meat its various colors. The myoglobin molecule is an atom of iron surrounded by a complex of pyrrole rings. **It is this iron that gives myoglobin the capacity to lose and gain electrons and combine with various chemicals. In living tissues, myoglobin is the storehouse for oxygen that is used in the normal biochemical processes of the living muscle.**

Because muscle differs greatly in activity, the oxygen demand differs greatly. This accounts for different myoglobin concentrations found in different muscles of the body. The back muscle (loin, etc) is used primarily for support and posture and, therefore has a much lower oxygen need than a leg muscle (ham or shoulder) used for movement or for that matter the heart muscle used for pumping blood. **The greater the myoglobin concentration, the more intense the colour.** The difference in myoglobin concentration is why we often find a two-toned effect in some cuts of meat where, one muscle group is lighter or darker than another.

Myoglobin concentration in muscle also differs among animal species. Beef has considerably more myoglobin than pork or lamb, thus giving beef a more intense colour. The final color intensity of a cured meat product can depend largely on which muscles of the carcass are used.

In muscles immediately after slaughter, the meat colour is quite dark – beef would be a deep purplish-red. As oxygen from the air comes in contact with exposed meat surfaces, it is absorbed and combines with myoglobin turning to a brighter colour. **This brighter red pigment is called OXYMYOGLOBIN – in beef, a bright cherry-red colour.**

Myoglobin and oxymyoglobin have the capacity to lose an electron (called oxidation) which turn the pigment to a brown color called metmyoglobin. Thus myoglobin can be changed from a dark purple color to a bright red color to a brown color by losing or gaining electrons and oxygen. The pigments myoglobin, oxymyoglobin and metmyoglobin can all be changed from one to the other when the appropriate conditions exist until the meat is heated to cooking temperature. Then a brown pigment called denatured metmyoglobin is formed which normally cannot be changed to form another pigment. Oxymyoglobin, commonly known as the fresh meat

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color, is the most desirable color for fresh meats. Maintaining this color requires that the meat surface be free from any contamination which would cause an oxidation reaction resulting in the formation of the brown pigment metmyoglobin. Also oxygen in the air must be available to combine with the myoglobin, forming oxymyoglobin. This reaction is reversible and dependent on availability of oxygen. This is why vacuum packaged fresh meat is usually the dark, purple-red color we associate with a freshly cut meat surface. Once the meat is taken out of the vacuum package, it will recover its bright red color.

Just as oxygen can bind to myoglobin or metmyoglobin, other chemicals can also bind. Most important of these is nitric oxide. When nitric oxide combines with myoglobin or metmyoglobin, a red pigment is formed called nitrosmyoglobin. Nitrosmyoglobin is not stable and may be easily converted back to myoglobin or metmyoglobin unless it is heated. Heating to 130° – 140°F results in the formation of the stable pigment nitrosohemochrome. This is also the temperature at which meat proteins begin to coagulate. Nitrosohemochrome, which is a pinkish color, is the commonly known cured meat color and its formation is what we refer to as the curing reaction.

Nitric oxide is a dangerously toxic gas and difficult to handle. It can be uniformly distributed within a cured meat when added in the form of a nitrite salt such as sodium or potassium nitrite. These salts are rapidly changed to nitric oxide in the meat. Nitrates are another source of nitric oxide by they must first be changed to nitrites.

Nitrosohemochrome is a stable compound, however, long exposure to high intensity light or oxygen will cause an oxidation reaction resulting in the pigment turning to an undesirable grayish-brown color.

Packaging

It is important to package cured meat in packages not permeable to oxygen and preferably a vacuum package. These in turn should not be exposed to intense direct light. Oxidation will also occur from bacterial growth causing color degradation.

A vacuum package serves as the best protection for maintaining the color of cured meat. It will also discourage the growth of many of the common spoilage bacteria.

INTRODICTION TO MEAT CURING

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Meat curing may be defined as the addition of salt to meat for the purpose for preservation [**Osmotic Dehydration**]. The origin of curing meats by salting is unknown and may have been initiated quite by chance. As the art progressed, additional substances were added to meat for curing purposes. As a result, the term meat curing eventually came to be understood as the addition of salt, nitrate, sugar, or in some instances, other ingredients for the purpose of preservation and flavoring meat.

In the early 1900's, it became known that nitrite accumulated in meat and meat curing brines containing nitrate. Subsequent work (Lewis and Vose, 1926) indicated that the nitrite resulted from bacterial reduction of nitrate and that nitrite was responsible for he production of the thermally stable meat pigment in cured meats.

With the advent of efficient and widespread refrigeration, the need for preserving meat by curing alone has greatly diminished, and factors such as flavour, colour and yield have become of much greater relative importance, than the amount of preservative provided.

RAW MATERIAL SELECTION AND PREPARATION FOR HIGH-QUALITY CURED MEATS

Meat preservation can be conducted with any type of fresh meat; pork, beef, chicken or turkey for example. To produce the highest quality cured meat, it is important that every step, i.e. the selection of the live animal, the butchering and the curing, are handled with the utmost care and attention.

The following points are important and should be considered:

1)Be sure that the animals are quiet and are in a condition ready for slaughter.
Most plants usually pass an electric shock known as 'stunning', prior to kill;

2)The job of butchering, bleeding and cleaning should be handled efficiently and promptly since the natural bacterial action that causes decomposition and spoilage sets in immediately after the animal is killed;

3) The meat should be chilled as quickly and as thoroughly as possible. Thorough chilling of the meat arrests the natural bacterial action, and holds it in check until the curing ingredients have a chance to offset further bacterial multiplication;

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4)Do a good job of trimming and curing. Use high-quality ingredients;

5)In general, all meats should be cured at temperatures between 38-44ºF. Lower temperatures slow the curing process, while higher temperatures can cause spoilage.

METHODS OF MEAT CURING

There are three major methods of curing meat:

- the Dry Cure,
- the Brine Cure and
- Pumping.

The Dry Cure is the method most generally used, especially for heavier cuts of hams, shoulders and bacon. The Brine Cure is used for smaller pieces. The Stitch Pumping and Brine Cures may be used together to increase the rate of curing. The object of the curing process is to uniformly distribute the curing ingredients through the meat.

The rate of curing depends upon the rate of diffusion of the curing ingredients into the tissues. In turn the rate of diffusion of the curing ingredients depends upon the manner in which they are applied, the size of the cut, the amount of fat covering, and the temperature.

The lowest rate of curing results when the curing agents are applied externally in the form of a dry rub or in liquid form as a cover pickle. Such methods of curing are still practiced for bacons and beef trimmings. For larger primal cuts such as hams, this method of curing may be vulnerable because of the possibility of bacterial spoilage before the cure penetrates effectively.

TECHNIQUES OF CURING

Dry Cure:-

Of the methods in use the oldest is that of dry curing. In this procedure, the mixture of dry curing ingredients is spread on, or more correctly, rubbed into the surface of the piece of meat to be cured and the meat held under refrigeration until the salt and other materials penetrate to the centre.

Penetration rate is dependent on time and temperature. The higher the temperature, the more rapid the penetration. Most recommendations give a time-weight relationship for curing. It is found that it requires a minimum of

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forty (40) days for salt concentration in the center of hams to approach the one percent level regardless of weight. At the same time, the salt concentration in the outer layer of the ham was 5 to 7 percent. Penetration of salt from the skin side of the meat is considerably slower than from the lean side. In fact, both skin and fat make relatively effective barriers for cure penetration.

In dry cured meats, the curing moisture is applied to the surface in one-, two- or five-day intervals by a rubbing process. The amount applied is dependent upon the final salt concentration required. Usually a dry cured product will use upwards of 3% salt based on original green weight. The addition of ascorbates or phosphates is not recommended. The curing mixture consists of salt, sugar and nitrate. While nitrite could be used, the curing time is sufficient for nitrate to be broken down to nitrite by bacterial action.

After rubbing with the cure, the products are stacked on shelves or in boxes and held for the previously-mentioned curing time, usually a temperature of 2ºC-4ºC when the curing is completed, large pieces such as hams and shoulders, are held under refrigeration for an additional thirty (30) days to allow the salt concentration to equalize. Following salt equalization, the products are then smoked and aged as desired.

Dry curing is sometimes used in conjunction with brine injection for some specialty products. In this procedure, the product is usually pumped with not more than ten percent of a fairly strong brine. The balance of the curing ingredients are then applied as a rub and the product handled much like dry cured.

Brine Soaking:-

This procedure has been used commercially for many years. In brine soaking, the product is placed in a brine solution for a length of time, usually 3-5 days until the brine penetrates the entire product. Brine soaking is used for small items such as corned beef, tongues, pickled beef or pork. Brine strength is variable depending on the desired saltiness of the finished product. With this method, there is a tendency to want to reuse the brine. This is not a wise practice for several reasons. First of all, the strength of the brine is reduced since some of the curing agents have been incorporated into the meat. Also, the brine at this point has been diluted with meat juices. Finally, the brine has been contaminated with bacteria which is absolutely unavoidable.

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Brine Injection:-

One of the critical factors involved in curing is the uniform incorporation of the curing ingredients into the meat itself. It is logical that the forcing of the brine directly into the meat would be advantage. Without brine injection, rapid curing would be unknown. The figure below shows the five (5) injection angles into a leg and shoulder carcass to be cured.

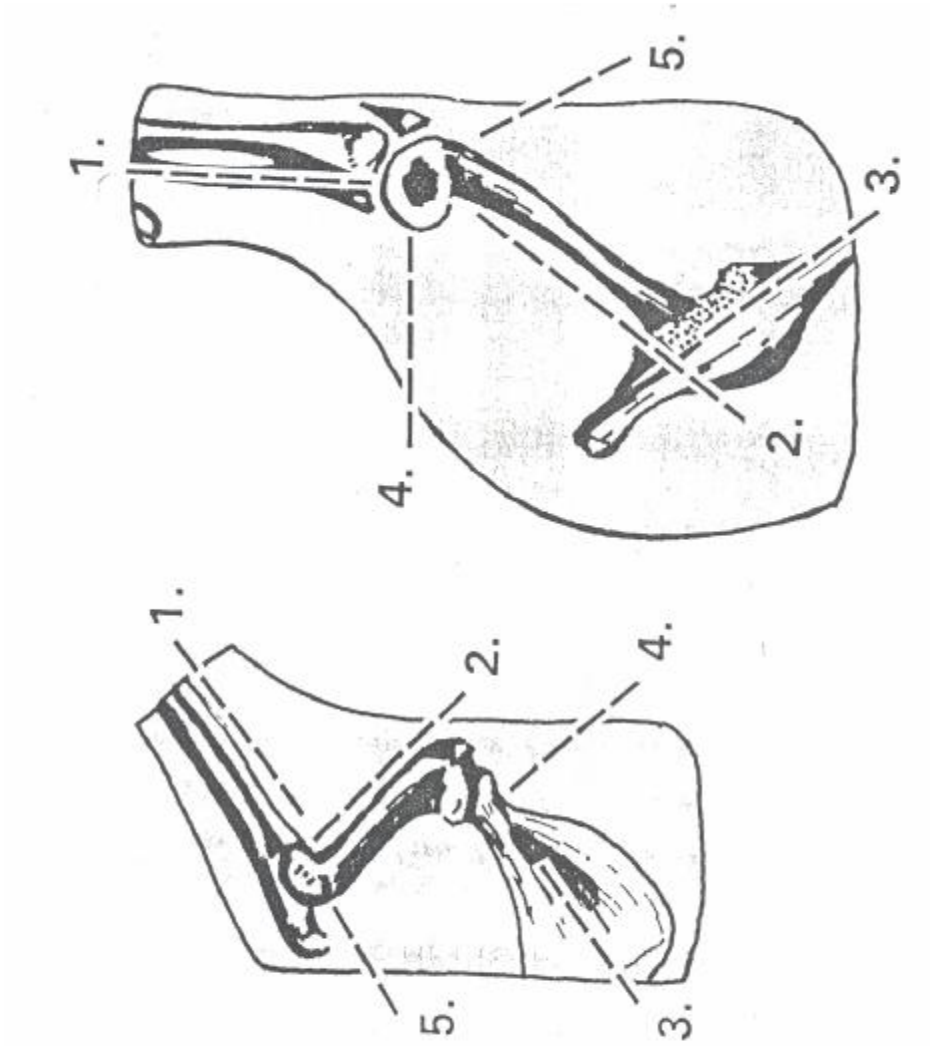

Figure: Figure showing the Five (5) injection points into a Leg and Shoulder of a Carcass to be cured

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Stitch Pumping:-

With this procedure, the brine is pumped into the meat with a needle that has a number of hole along its length. Sometimes gangs of needles are employed. Usually the injections are made at several sites as close as possible.

Artery Pumping:-

In Artery Pumping, the brine is injected through the femoral artery and follows the arterial system throughout the ham. It must be noted that arterial pumping is not uniform in its distribution. Most plants usually hold twenty-four hours for curing after arterial pumping. However, 5 to 7 days after pumping will greatly improve uniformity of cure distribution. In order to get a successful job of artery pumping, it requires careful workmanship during slaughter, cutting and subsequent handling to ensure that the arteries are intact. Under conditions of freezing, damage can be caused to arteries.

Machine Pumping:-

The advent of relatively low cost continuous brine injection machines offers the processor an opportunity for rapid processing of hams, bellies and other cured meat items. The principle used is similar to spray pumping with the exception that the needles inject the brine at hundreds of points. The pressure of the brine forces relatively uniform brine distribution throughout the meat.

FUNCTIONS OF CURING INGREDIENTS

Salt

Salt is the primary ingredient used in meat curing. To function completely as a preservative, we need a brine concentration in the product of 17% minimum. Salt is however, used to impart flavor. In most cured meat products a finished concentration of 2 to 3 percent is used.

To determine salt levels of a salt brine, a salometer or hydrometer is used. The presence of sugar in a brine will also affect the hydrometer reading. Sugar added to a brine will raise the readings about one-half as much as an equal amount of salt will. Nitrates, nitrites, ascorbates, etc., will affect the readings but the level at which they are added is not high enough to make them a substantial factor in calculating brine strength.

Impurities in salt in the form of traces of copper, iron and chromium have a marked effect on the development of oxidative rancidity in cured meat

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products. This is one of the reasons that cured meats do not hold up for as long a period of tie as fresh meats when held in freezer storage. If rancidity is critical, it is possible to purchase low proxidant salts which have these heavy metal ions removed.

Nitrates and Nitrites

Nitrates and nitrites must be used with caution during coloring. Both are poisonous and therefore strict limits have been established. Excessive use of nitrates and nitrites could not only present a health hazard but also may result in nitrite burn which is a green or white discoloration of the cured meat. Nitrates and nitrites have a pronounced effect on flavor by acting as powerful antioxidants. Antioxidants are compounds that prevent the development of oxidative rancidity.

The bacteriostatic properties of nitrites are also critical. Sodium nitrite is a very effective inhibitor of the growth of *Clostridi*a, particularly *Clostridium botulinum*.

Sugar

Sugar (sucrose) serves several important purposes in cured meats. First it adds flavour and secondly it helps overcome saltiness.

Flavourings

It has become increasingly popular to add various flavourings and spices to cured meat, particularly hams. Most common flavourings are pepper, cloves allspice and cinnamon, garlic and onion.

The use of flavouring is a matter of taste. Care should be taken so as not to overpower the natural cured meat flavour.

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Table: Ingredients for the Production of Cooked, Cured Beef.

Ingredients	**Quantity of ingredients per 10kg batch of finished product**
Lean meat	10.7kg
Pumping Brine	
Nitrite Salt	130g
Sugar	2.5kg
Whole black pepper	
Bay leaves	To taste
Dried mace	
Majoram	
Water	1.0 Litre
Immersion brine	
Nitrite salt	2.680kg
Sugar	52g
Whole black pepper	
Bay leaves	
Dried mace	To taste
Majoram	

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Water	20 Litres

Weight of finished product: 10kg
Yield of finished product: 94% on meat ingredients (this allows for salt uptake during pumping, etc.)
Estimated carcase cut-out of meat input: 82%
Carcase meat "bone-in" required:10.7 kg÷0.02 = 13 kg
Yield on carcase meat "bone-in" = (10÷13) x 100 = 77%

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