Meat quality

In recent years, meat quality has assumed a greater consumer significance and public attention there is growing awareness of the link between diet and health and this is reflected in the demand for more information and for products which are healthy and of consistently high quality. As a consequence, this has lead to the demand for meat with a high lean content. On the other hand as animals, and especially pigs and poultry, have become leaner, more complaints have been received that the eating quality of the meat has declined, with complaints of dryness, toughness and lack of taste and flavour. Other concerns are about food safety and hygiene, especially the presence of micro-organisms, bacaterial contamination and residues, as well as the welfare and husbandry conditions under which animals are kept. Thus, both the diets fed to the animals and the systems of animal production are being increasingly questioned. It is fortuitous that with the elucidation of the major factors influencing meat quality and hygiene new opportunities are being created for the development of a consistent, healthy, safe and attractive product which offers value for money.

Factors contributing to the eating quality of meat are:

1. Appearance
2. flavour (smell at abattoir, taste)
3. tenderness (chew time)
4. texture

Appearance: this has to do with the colour of meat and its freshness. Colour is determined by the concentration of myoglobin. In young animals there is little concentration of myoglobin, but greater in older animals and the meat becomes darker.

Flavour: flavour is the combined result of the taste and smell senses and, because it is a subjective property, is difficult to evaluate. Eache species has its own characteristic flavour. Chemical reactions resulting in some 1,000 compounds during contribute to te individual meat's flavour

Tenderness: the meat from the young animals is more tender that the meat from old animals. At time of cooking a lot of connective tissues will become soft especially meat from the young animals. Connective tissues are easily broken in meat of young animals than the older animals because they do not easily disintegrate.

Texture: this has to do with the diameter of muscle fibre when muscle are associated with closely packed diameter. It is called fine texture and it is usually of young animals. Course texture is associated with wider diameter of muscle and its is usually meat of older animals.

Hofmann (1987) and Russo (1988) have broadly classified meat quality characteristics into four main categories:

- Organoleptic properties
- Technological quality
- Nutritive value
- Hygienic characteristics or food safety aspects

Organoleptic properties are the traits that influence the consumer to regularly purchase and eat meat. Technological qualities refers to the suitability of meat for further processing and are primarily determined by treatment after slaughter. Nutritional value concerns with the chemical composition of the meat and its suitability for human consumption. Hygiene or safety implies freedom from harmful microorganisms and any residues. These can be controlled through legislation, proper feeding designs and strategies, quality management schemes on the farm and procedures in the slaughterhouse and processing plant.

Components of meat quality

The main factors contributing to the eating quality of meat are tenderness, juiciness and colour. These are dependent upon several metabolic and biological phenomena within the animal or carcass and include the following:

- Intramuscular content or marbling fat
- Taint, especially the content of skatole, indole and testosterone
- The type and fatty acid content of the animal's diet and hence its carcass
- Maturation or conditioning effects
- Drip loss and maintenance of the integrity of the cell membrane post-morten
- Stress, during transportation and lairage
- The potential to flavour meat
- The effect of feeding

Marbling fat: acceptability in pigs, the effect of fat on eating quality depend on amount of marbling fat. Marbling fat is the lipid found in the connective tissue sorrounding the muscle fibre bundle. It has been suggested that at least 2.0% marbling fat is required for optimal eating quality. Studies have shown that the lower the backfat thickness, the lower the percentage of marbling fat and the less the overall acceptability of the pork.

Taint and effect of skatole: Skatole (3-methyl indole) is a volatile compound produced in the hindgut of animal by microbial degradation of the amino acid tryptophan. Majority of skatole is degraded in the liver and excreted in the urine; the undegraded portion is deposited in the fat and muscle of the body. High concentrations in these tissues give rise to unpleasant smell and taste of meat, especially in entire male animals. Several studies has shown the effect of different diet component on skatole concentration in the intestinal contents, as well as faeces and backfat of pig, e.g. fibre and cp content.

Fatty and composition:

In non-ruminants it is well established that simply changing the type and quantity of oil and fat in the diet can change the fatty acid content of fat in the carcass. High concentration of polyunsaturated fatty acids have been associated with values for tenderness, juiciness, flavour and overall acceptability; whereas high concentration of saturated and monounsaturated fatty acids resulted in high overall score. Also, there is an increased risk of rancidity and 'off' flavour when oils are used in high quantity in pig diets.

Maturation and conditioning effects

The tenderness of meat improves with conditioning and storage after slaughter. Increasing the conditioning period from 1 to 10 days at $1^{o}C$ significantly improves the overall liking of meat. Also the injection of calcium salt solutions, such as calcium chloride, into the carcass of animals have been found to significantly improve the eating quality of meat and reduced the toughening effect of cooking.

Oxidation stabilization and Drip loss

Lipids are important components of meat and enhance several desirable characteristic such as flavour, tenderness and juiciness. However, one of the major cause of deterioration of meat, even during cold storage, is lipid oxidation which ultimately results in unacceptable flavour, odours and fatty acids, fat soluble vitamins and pigments. There is also concern about the production of peroxides and aldehydes and the form ation of 'free radicals' which produce harmful chemical products.

Lipid oxidation is therefore a major cause of deterioration in the quality of meat. it also influences the yield of saleable meat, since the disruption of the subcellular membrane destroys the integrity of the cell wall, releasing intracellular fluid. This results in considerable fluid or drip loss, a major problem and economic loss in both poultry and pork. It is therefore beneficial to reduce both the occurrence and rate of lipid oxidation.

The role of vitamin E and Selenium as antioxidant is recognized and feeding of high dietary levels to both pig and poultry has improved meat quality by reducing the rate of lipid oxidation and maintaining the integrity of the cell membrane post-slaughter. This resulted in the meat keeping its fresh appearance and colour for longer, as well as reduced drip loss, allowing better presentation of both poultry and pork.

Stress

The most effective way to reduce the incidence of poor pork quantity is to improve pre-slaughter management and handling and thereby reduce stress. Stress both during transportation and pre-slaughter can affect meat quality, since it can influence the rate and extent of post-mortem acidification in the muscle. If stress is induced over a long period, then muscle glycogen is depleted and dark, firm and dry (DFD) meat may result. Similarly, if the stress occur immediately b/4 or at slaughter, then the rate glycolysis is increased at a time when carcass temperature is high, resulting in PSE meat. Chromium has been recognized as an element which can assist animal to better tolerate stress, therefore reducing stress occurrence in animals, especially the organinc form and minimizing the incidence of both PSE and DFD-type meat.

Effects of Feeding

The supply of nutrients to animals, influence carcass composition since it directly affects growth rate as well as the proportion of protein and fat in the body. The higher the level of feeding, the higher the rate of lean and fat gain, and therefore the higher the eating quality of the meat. it has also been proved that the quality and type of raw ingredients included in the diets rather than the feeding levels per se was response for the effects.

Meat preservation

Meat get putrifies due to the action of bacteria, moulds and yeasts. In an effort to get nourishment fro the meat after the meat alter the meat in various ways. To grow they require favourable temperature. It is therefore customary to classify organisms according to their temperature tolerance:

1. *Psychrophiles* which have an optimum temperature range of -2^{o}C to 7^{o}C.
2. *Mesophiles* which have an optimum temperature range of 10^{o}C to 40^{o}C
3. *Thermophiles* which have an optimum temperature range of 43^{o}C to 66^{o}C.

One can them preserve meat by reaching -2^{O}C (sub optimal temp.) by chilling or freezing and 66^{O}C(super optimal temp.) by pasteurizing, cooking or sterilizing

Organisms also need water for growth and so it is possible to preserve meat by removing this by dehydration, freezing or curing.

Organisms causes spoilage by:

- by disintegration in the connective tissue
- produce gases as hydrogen suphide, carbon dioxide, ammonia e.t.c
- ferment the muscle sugar (glycogen) to produce acetic and butyric acids, causing offensive smell and tastes.
- Discolouration of t he meat by chang in the myoglobin

Preservation by cold

Simplest form of meat preservation. And it can be done for long time. This because bacteria are unable to multiple at low temperature and due mainly to the fact that water is changed to ice.

1. Chilling meat: It is useful when meat will be preserved for only 35days. It loses very little in appearance, nutritive value and taste. It is kept between -1.4^{o}C and 1^{o}C, preferably in the dark as light has the effect of oxidizing fats. The atmosphere should be kept dry. A concentration of 5% to 10% carbon dioxide helps to prevent the growth of mould and bacteria. Meats under this condition require more space as they will need be hung on hooks to allow for adequate air circulation around them.
2. Freezing of meat: Temperature for ordinary freezing vary between -18^{O}C and -5^{O}C. This can be kept for a long time. Frozen Beef can be stored for 12 months, veal slightly less, mutton and lamb 8 months and pork 6 months without much deterioration. Frozen meat stored too long become dry, less palatable and rancid. It is less durable after thawing than fresh killed or chilled meat. Slow freezing or blast freezing can be used.

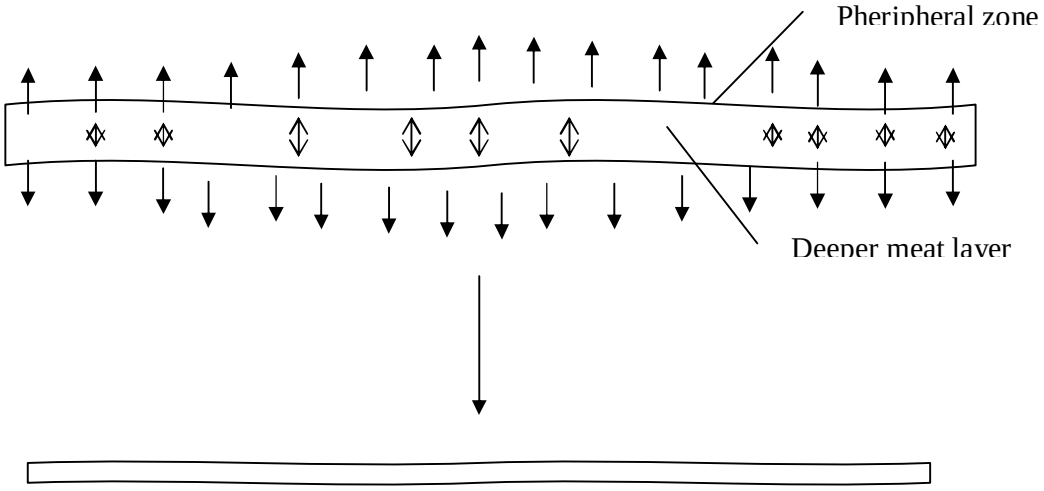
Preservation by Drying

Simple techniques for production of dried meat

Temperature, humidity and circulation of air are the key factors in drying of meat. gradual dehydration of meat cut to specific uniform shape that permits the equal and simultaneous drying of whole batches of meat. The optimal condition for a successful and easy drying of meat is are:

- Relative humidty of 30%
- Warm and dry air
- Small temperature difference between night and day.

Drying will be faster under high terperatures, low humidity and intensive air circulation.



Relative high water evaporation in the first day of drying, after which evaporation rate continually decreases. As the meat dries it becomes smaller, thinner, thinner and to some degree wrinkled. Consistency also changes from soft to firm and to hard.

Important steps in meat drying:

i) slaughtering of the animal ii) carcass trimming iii) Selection of the raw materials iv) proper cutting and pre-treatment of the pices v) proper arrangement of drying facilities vi) Influence of unfavourable weather most be considered in order avoid quality problem or production losses

The secret of correct meat drying lies in maintaining a balance between water evaporation on the meat surface and migration of water from the deeper layers. In other words, care must be taken that meat surfaces do not become too dry while there is still a high moisture content inside the meat pieces. Dry surfaces inhibit the further evaporation of moisture, which may result in products not uniformly dried and in microbiological spoilage starting from the areas where the moisture content remains too high.

Selection of meat for drying

Lean meat without visible fat tissues adhering to muscle are suitable for drying.

- Bovine meat, sheep, cameloids, goats and venison (e.g antilopes, dear etc.) is also used.
- Meat from medium aged animal, in good condition and not fat.
- Meat must be examined for undesirable alterations as discolouration, haemorrhagic spots, off-flavour, manifestation of parasites e.t.c. such defects must be trimmed off.

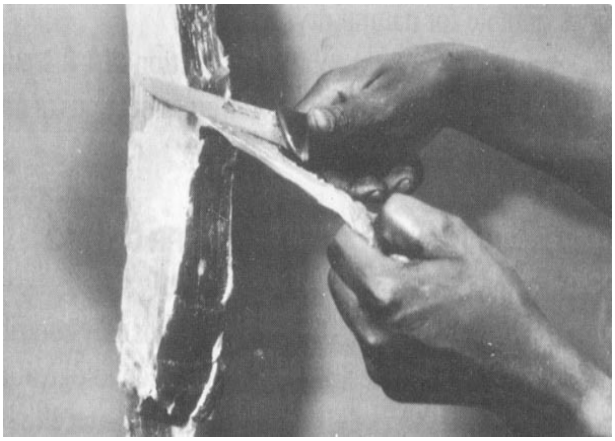
Techniques of cutting meat pieces for drying

Cutting muscle into thin strips ca be done in two ways:

- Cutting after placing mea on clean chopping board (Fig 1)
- Cutting the muscle in hanging position (Fig 2)

In both cases the muscle have to be split along the muscle fibre and must be uniform and smooth as possible. Length of strip may differ but not less than 20cm an not more than 70cm.

FIG 1. Cutting meat streeps from the muscle on a chopping board. FIG 2. Cutting meat streeps from a suspended muscle.



In both cases the muscles have to be split exactly along the muscle fibres. The strips must be cut as uniformly and as smoothly as possible and the diameter of the strip must remain the same throughout the length. The length of the strips may differ, though it should not be less than 20 cm and not more than 70 cm. Meat cut into shorter strips requires considerably more time for hooking than the same quantity cut into longer strips. However, strips which are too long may break because of their weight.

Recommended Treatment before drying

Pre-salting: the use of a 14% salt solution is preferred. It is bactericidal in action and also protect against insect during drying. The necessary amount of edible salt is added to water and dissolved by intensive stirring, the meat strips are dipped into solution, soaked for about five minutes and then drained. Draining can be done using plastic sieve.

To make 14% of salt solution below are the volumes of water to the weight of salt:

Water (l)	**Salt (g)**
5	810
6	975
7	1140
10	1630

FIG.3 Suspension of meat strips on hooks (A), loops (B), and by means of clips (C).

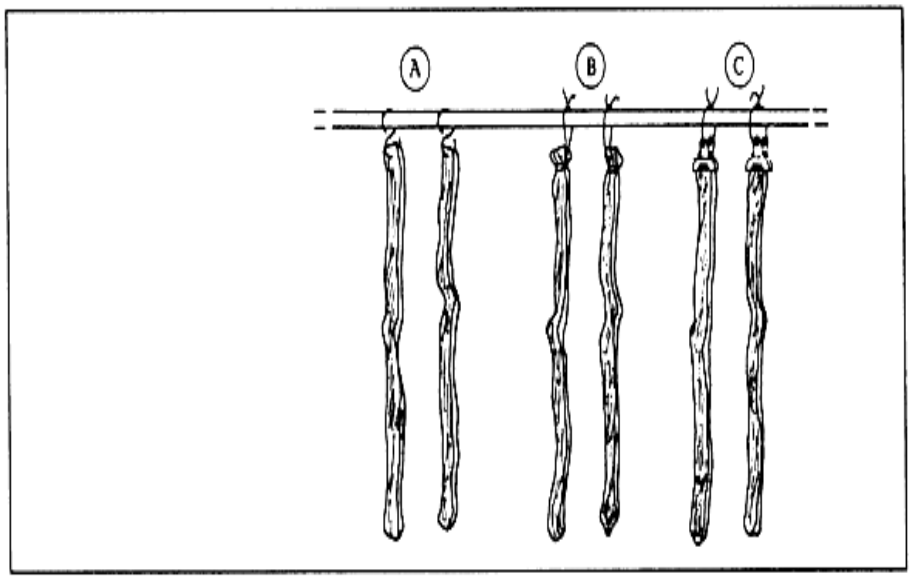
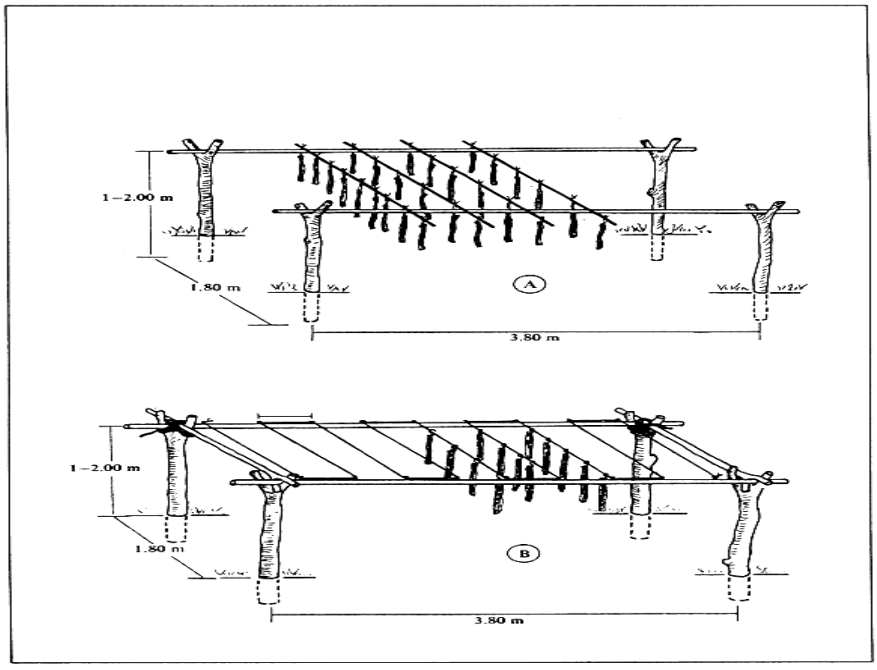


Fig 4: Sun meat dryer made of wood or metal (A and B)



Methods of suspending of meat strips for drying

Meat should be suspended individually from one end, thus ensuring, through arrangement on the drying facility, free air circulation along the whole length of the pieces and fat and uniform drying. The contact of meat pieces with each other must be avoided.

The suspension of meat strips can be done in different ways (Fig 3):

- ✓ Suspension using metal hooks
- ✓ Suspension using loops
- ✓ Suspension using metal clips

Installation for drying entire batches of meat

- ✓ Sun meat dryer made of wood or metal
- ✓ Mobile meat dryer

Meat dryer with protection against extreme influence e.g roof typ or normal with protection.

Quality of the final products

- ✓ Appearance: absence of large wrinkles and notches indicate uniform dehydration of meat
- ✓ Colour: the surface and cross cut, should be uniform and dark red.
- ✓ Taste and flavour: mild salty taste when spices are not added. No off-flavour. Some rancid flavour might occur.

Dried meat must be continuously examined for spoilage-related off-odour, which is the result of incorrect preparation and/or drying of the meat. Meat with signs of deterioration must be rigorously sorted out.

Packaging and storage

This serve to protect against contamination.

Paper, plastic foils, aluminium foils, cellophane and textiles. Vacuum packaging give longer shelf-life. Cardboard can be used. Prevention of wet condition setting inorder to prevent bacteria and mould under storage.

Meat drying in combination with additional treatment

i) pre-salting ii) cured dried meat iii) smoked dried meat iv) dried meat with spices and additive e.g Kilishi

Meat Preservation By Thermal Treatment

Characteristics of Heat-Treated Preserved Meat and Meat Products

The prolonged shelf-life of heat-treated meat and meat products is achieved through reducing growth of, or inactivating, micro-organisms by a thermal process. The principal steps of the heat preservation method are to:

- place the product in a container (can, glass jar, pouches of synthetic material or laminate with aluminium) which is hermetically sealed after filling and which is impermeable to any external substances; and

- submit the hermetically sealed product to thermal treatment with a defined temperature and time combination.

EQUIPMENT FOR THERMAL TREATMENT

Thermal or heat treatment is done by submerging the products in cooking vats or pressure cookers which contain hot water or steam or a mixture of both. It can be performed under pressure in pressure cookers (retorts, autoclaves) in order to reach temperatures above 100°C ("sterilization"). Sterilization is the most important and efficient type of heat treatment, since foods free from viable micro-organisms can be obtained and most of these products can then be stored without refrigeration. In contrast, temperatures up to 100°C can be achieved in simple cooking vats ("pasteurization"). A certain amount of micro-organisms resist this moderate heat treatment and the resulting pasteurized products must consequently be stored under controlled temperatures.

After thermal treatment the product must be chilled as quickly as possible, in order to avoid overcooking. Hence, this operation is done within the cooker by introducing cold water. The contact of cold water with steam causes the latter to condense with a rapid pressure drop in the retort. A high pressure difference between the cooker and the internal pressure in the containers must be avoided inorder not to induce permanent deformation or damage of these containers.

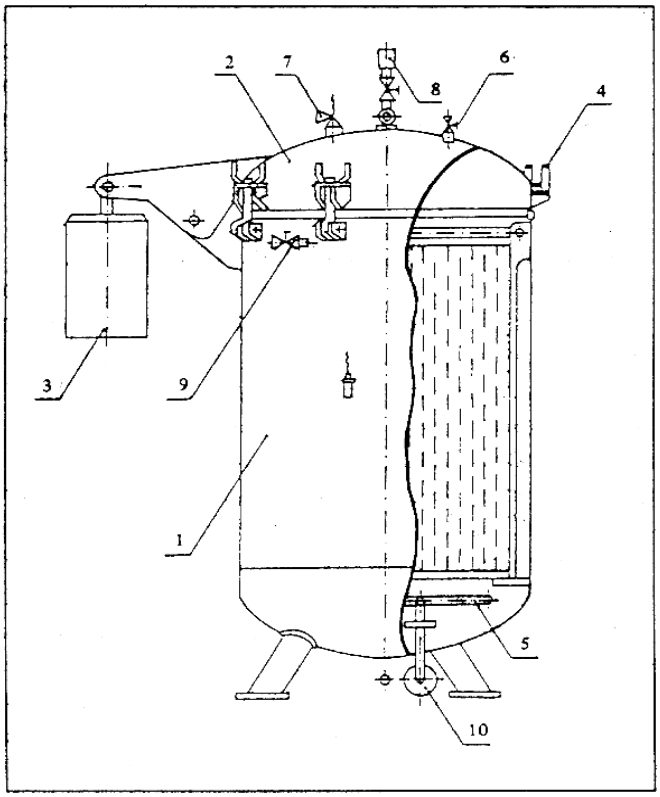


FIG.1. Retort cooker. 1. body, 2. lid, 3. counterbalance, 4. nuts, 5. heater, 6. vent, 7. relief valve, 8. pressure gauge, 9. water supplyvalve 10. steam supply valve.

CONTAINERS FOR THERMALLY TREATED PRESERVES

Containers for heat-preserved food must be airtight in order to avoid recontamination by environmental microflora. Moreover, no traces of undesirable substances which the packaging material may contain, such as heavy metals (lead, tin), should be permitted to migrate into the product. Currently, most of the thermally preserved products are in metal containers are:

i. Cans,

ii. Glass jars or plastic or

iii. Aluminium/plastic laminated pouches.

The advantages of aluminium cans are low weight, resistance to corrosion, good thermal conductivity and recyclability, but these cans cannot be soldered or welded. They are less rigid and more expensive than steel plate.

MEAT PRODUCTS SUITABLE FOR CANNING

- cooked ham
- sausages with brine of the frankfurter type
- sausage mix of the bologna or liver sausage type
- meat preparations such as corned beef, chopped pork, etc.
- ready-to-eat dishes with meat ingredients such as beef in gravy, chicken with rice, etc.
- soups with meat ingredients such as chicken soup, oxtail soup, etc.

ORGANOLEPTIC, PHYSICAL AND MICROBIOLOGICAL ASPECTS OF THERMAL TREATMENT

The intensity of heat treatment has not only a decisive impact on the inactivation of micro-organisms, but also on the organoleptic quality of the product. As a result:

1) There are products which undergo intensive temperature treatment without significant losses in quality.

2) Some other products may deteriorate considerably in taste and consistency after sterilization. In these cases less intensive thermal treatment is required but, at the same time, other hurdles, such as low pH value and/or water activity or a lower storage temperature, have to be built up in order to inhibit bacterial growth.

The intensity of thermal treatment can be defined in physical terms. The term widely used under practical conditions is the F-value, with which the lethal effect of heat on micro-organisms can be defined. The thermal death time for different micro-organisms calculated at 121°C and expressed in minutes, is used as the reference value.

The thermal death time for spores of *Clostridium botulinum* at 121°C is 2.45 minutes or in other words, an F-value of 2.45 is needed to inactivate all these spores in the product at 121°C. Spores of other micro-organisms are more or less heat resistant. Vegetative cells of micro-organisms are generally destroyed at temperatures of less than 100°C and therefore play no role in the F-value calculations. The definition of the F-value at121°C is as follows:
F = 1: lethal effect at 121°C on micro-organisms after 1 minute
F = 2(3, 4, etc.): lethal effect at 121°C on micro-organisms after
2(3, 4, etc.) minutes.

The lethal effect can be shown in the reduction (in percentage) of the total number of micro-organisms present in the product. The destruction of micro-organisms is at an exponential rate, which means that the higher the initial bacterial load (using the same time-temperature combination), the higher the number of surviving bacteria.

Table 1. **Decimal reduction rates during heat treatment**

	Remaining micro-organisms		
Initial bacterial load (micro-organisms/g)	**Destruction rate 90””%**	**Destruction rate 99%**	**Destruction rate 99.9%**
10 million	1 million	100 000	10 000
1 million	100 000	10 000	1 000
100 000	10 000	1 000	100
10 000	1 000	100	10
1 000	100	10	1

The initial bacterial load and the destruction rate are shown in Table 1.

Table 1 demonstrates the importance of proper meat hygiene. Highly contaminated raw material with bacterial loads of 10 million per g will, even after intensive heat treatment, still give final products with a rather limited shelf-life because of the high remaining rate of contamination.

Since the heat treatments will in many cases not be intense enough to destroy all spores, it is important that cans be chilled as rapidly as possible after retorting and that storage temperatures generally not exceed 20 to 25°C.

The nature of the heat-preserved product, its pH, amount of salt and other curing agents, and the number of spores present, together with retorting time and temperature, determine the degree of commercial sterility and product safety. It has been shown that F-values of 4 in heat-preserved products will guarantee commercial sterility. Products with F-values below this level need additional measures such as lowering the pH or the a_w or refrigerated storage for their microbiological safety.

Micro-organisms have two adverse effects in improperly treated heat-preserved products:

- organoleptic deterioration through protein degradation;
- food poisoning by bacteria and/or toxins.

CATEGORIES OF HEAT-TREATED PRESERVES

Pasteurized products

Only slight thermal treatment. Temperatures reached in the product centre are in the range of 82°C and below 100°C (“pasteurization”). The F-value cannot be determined, remaining almost at zero.

Inactivated: most vegetative micro-organisms
Not inactivated: spores of *Bacillus* and *Clostridium*
Storage required: uninterrupted cold chain (2–4°C), up to six months

Cooked preserves

Thermal treatment only with boiling water (no pressure cooker).

Temperature reached in the product centre is up to 100°C. Low F-value.

Inactivated: all vegetative micro-organisms
Not inactivated: spores of *Bacillus* and *Clostridium*
Storage required: not higher than 10°C for one year. Spores will not grow under these conditions.

"Three-quarter" preserves

Thermal treatment in pressure cooker. Temperatures reached in the product centre are between 108 and 112°C. F-value 0.6 to 0.8.

Inactivated: all vegetative micro-organisms, spores of *Bacillus*
Not inactivated: spores of *Clostridium*
Storage required: not higher than 15°C for one year. Spores of *Clostridium* will not grow under these conditions.

"Full" preserves stable under temperate conditions

Intensive thermal treatment in pressure cooker. Temperature reached in the product centre is about 121°C. F-value 4 to 6 ("sterilized product").

Inactivated: all micro-organisms except thermophilic spores
Storage required: ambient temperature (for one year), but not tropical conditions (40°C or more).

"Full" preserves stable under tropical conditions

Very intensive thermal treatment, with a long period of 121°C or higher in the product centre. F-value of 12 and more.

Inactivated: all micro-organisms including thermophilic spores
Storage required: ambient temperature even under tropical conditions (up to four years).

Shelf-stable preserves

This group of preserves is different from those mentioned previously, since preservation is achieved not only by thermal treatment, but also by utilizing other means to prevent microbiological growth such as nitrite, low water activity and/or low pH. This combined effect has the advantage of a fully shelf-stable product under all ambiental conditions without undergoing intensive thermal treatment (less than 100°C) and without major losses in organoleptic quality.

FACTORS AFFECTING THE SHELF-LIFE OF MEAT AND MEAT PRODUCTS

Though meat handling, storage and consumption may differ from one place to another, the factors limiting the shelf-life of these products are the same.

There are *endogenous* factors, such as:

- pH-value or the degree of acidity of the product;
- a_w value or the amount of moisture available in the product; and *exogenous* factors, such as:

- oxygen (from the air);
- micro-organisms;
- temperature;
- light; and

evaporation and desiccation.