Methods of preservation of meat

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Preservation plays a vital role in ensuring safety, controlling spoilage and extending the shelf-life of meat facilitates the distribution of meat to distant places.

The methods of meat preservation include drying, chilling, curing, fermentation, irradiation, chemical treatment and thermal processing (canning).

Drying- Drying refers to the removal of moisture (reduction in aw) from the food Dried foods are low moisture (LM) foods containing moisture less than 15%. Water activity (aw) of these foods varies between 0.50 and 0.60.

The final moisture content should be around 4%. It is essential to use hygienically processed meat with a very low microbial profile for preparing dried meat

Freeze dried meats are also included under this category.

The moisture level in freeze-dried meat may be about 2 to 8%. The aw value may be 0.10 to 0.25 .

There is another category of shelf-stable meats where moisture content varies from 15 – 50% and the aw is between 0.60 and 0.85. These are intermediate between dried and fresh foods. They are called Intermediate Moisture Foods (IMF).

Storage stability of dried meats is longer at ambient temperatures. However, apart from fungal growth as stated earlier, undesirable chemical changes may occur in dried meats duringstorage.

Oxidative rancidity is a common chemical spoilage occurring in meats rich in fats. Meats containing reducing sugars undergo a colour change known as maillard reaction or nonenzymatic browning. This is due to the interaction of the carboryl groups of reducing sugars with amino group of proteins and amino acids. These chemical changes can be minimized by keeping the moisture content as low as possible, reducing the level of reducing sugars and by applying modern packaging methods such as vacuum packing or modified atmosphere packaging (MAP).

Intermediate moisture meats (IMM). The intermediate moisture meats are shelf-stable at ambient temperatures for different periods of time Lower aw is achieved in these IMM products by withdrawal of water through desorption, adsorption and through the use of permissible additives (salts and sugars). Glycerol, glycol, sorbitol and sucrose are normally used as humectants to lower the aw. Apart from aw, several other conditions such as alteration in pH, use of preservatives, fermentation, irradiation and modern packaging systems are applied as hurdles (hurdle technology) for the growth of microorganisms and to enhance the

storage stability of IMM products.
The aw levels of IMM would not allow the growth of Gram-negative bacteria and most of Gram-positive bacteria except some cocci, some spore formers, and lactobacilli. Mold growth is a common problem in IMM.

Low temperature preservation-
Low temperatures preserve the food material by retarding the microbial growth, and the enzymatic and chemical reactions that deteriorate the meat and cause spoilage.

The most widely used methods based on this principle of preservation by low temperatures is refrigeration (chilling or icing) and freezing.

If the temperature of the meat is reduced below - 2.5 to - 2 °C it gets frozen changing the physical state of its tissues as well as the rate of enzymatic and chemical changes. Refrigeration / chilling refers to preservation of the meat by lowering the temperature of the meat to above the freezing point the chill room temperature remains between - 5 and - 2°C (before the carcasses are loaded) and the temperature of the chilling room should remain below 3°C at all times. relative humidity inside the chill room is maintained at 88 – 92%, so that dehydration and subsequent shrinkage of the carcasses is avoided.

2. Freezing. At chill temperature the meat is cooled to < 0°C. Meat starts freezing at - 1.5°C.

About half of the water is frozen to ice at - 2.5°C. Three quarters of it are frozen at - 7°C and some water still remains intact at - 18°C. Then the meat is further cooled to its storage temperature (- 18 to - 20 or - 30°C) till such time where its thermal center reaches the storage temperature.

Curing.
Historically, curing of meat developed as an art of preservation using salt. Salted meat undergoing complex ripening reactions assumed a sensory profile of its own, establishing itself as a product of distinct identity. Eventually other ingredients like nitrate, nitrite, sugar, phosphates, *etc., entered the curing mixture, each with a specific role to play in the curing p*rocess.
The entry of nitrate into the curing mixture was by accidental. It entered the mixture as an impurity of the rock salt used for curing. Its role as a colour-fixation agent (through conversion to nitrite by bacterial reduction) was recognized later. Eventually it got included as an essential ingredient in the curing mixtures.

1. **Meat pigments and stabilization of meat colour**
2. **Preservative functions of components**
3. **Components which improve organoleptic qualities.**

1. Meat pigments and stabilization of meat colour

myoglobin, residual haemoglobin, cytochrome-
Of these myoglobin is the most abundant. Myoglobin, like haemoglobin is a heme protein, consisting of globin (a protein) complexed to heme (an iron nucleus attached to a porphyrin ring)

In uncured meat (on exposure to atmospheric oxygen) the ferrous iron Fe^{2+} present in the heme moiety absorbs oxygen forming oxygenated myoglobin, which imparts a bright red colour to meat.

Eventually, the ferrous iron gets oxidized to ferric form, resulting in the formation of metmyoglobin, which is brownish in colour. Subsequent degradation of metmyoglobin leads to discolouration of meat.

Role of Nitrite in colour fixation. The mechanism in its simplest form is as follows:

- **The** nitric oxide (NO) provided by nitrite gets attached to Fe 2+ and blocks oxygenation of myoglobin and subsequent oxidation to metmyoglobin.

- The nitric oxide myoglobin so formed

- Transforms into a permanent pink compound called nitrosohemochrome which is the colour of the cured product following heat treatment.

- Ascorbic acid or ascorbate or erythorbate added as an ingredient in the curing mixture helps to maintain a reducing atmosphere.

- It also reduces any nitric oxide metmyoglobin that may be formed to nitric oxide myoglobin.

Preservative functions of components. Sodium chloride (salt) exerts inhibitory effect on bacterial growth by bringing down the water activity (aw). Nitrite plays an important role in retarding the growth of several bacteria, particularly Cl.*botulinum. The phenolic constituents in* smoke also have bactericidal action.

Components which improve organoleptic qualities. Phosphates improve the texture by
enhancing the water holding capacity (WHC) of muscle proteins. The phosphate raises the pH.
These result in unfolding the molecule and increasing the number of sites exposed both of which help to bind higher amount of water. Salt is a major component that imparts taste.
Sensory evaluation trials have established the role of nitrite in producing typical cured flavour. Smoke components, particularly phenols, aldehydes and ketones contribute to the development of flavour in smoke-cured products.

Antioxidants. Lipid oxidation leading to rancidity is a major deteriorative reaction in cured products. Heme compounds especially iron catalyze the autoxidation. The warmed over flavour (WOF) in cured meat has been related to oxidative rancidity. Nitrite acts as an antioxidant. The mechanism of its action is not fully understood. It has been suggested that the stabilization of porphyrins by nitrite remove the pro-oxidant action of iron. The smoke components, especially phenols may also act as antioxidants. The antioxidant activity of ascorbic acid is well known.

Toxic factors. Nitric oxide produced from nitrite reacts with secondary amines in meat and produces nitrosamines, which are carcinogenic. Food regulations in many countries restrict the use of nitrite to 200 mg / lit in final product. Benzpyrine components of wood smoke are other sources of toxins. These condensed aromatic hydrocarbons are well known carcinogens.

Nitrite substitutes. Due to the nitrosamine scare, search is on for substitutes for compounds which can emulate all the effects / functions of nitrite in cured meats. The potential alternatives suggested are (i) sorbic acid and sorbates, (ii) sodium hydrophosphite and (iii) fumarate esters. These compounds may be used with reduced nitrite levels. Irradiation has also been suggested with the use of lower nitrite levels. Acidulation by lactic acid-producing bacteria is another alternative approach in this regard.

Cured meat flavour. Apart from the role of nitrite, a number of volatile compounds have been identified that are responsible for imparting the cured flavour. They include ketones, aldehydes, bases and sulfur compounds.

The role of smoke. Wood contains cellulose (40 - 60%), hemicellulose (20 - 30%) and
lignin (20 - 30%). Smoke is generated by burning wood materials to temperatures ranging from 200 to - 400°C. The smoke generates two major phases : vapour and particle. All the volatile compounds are in vapour phase and the particle phase contains carbon, tar and the low volatile polycyclic hydrocarbons. The volatile fraction consists of phenols, alcohols, organic acids, carbonyls and lower hydrocarbons. Smoke components help in preservation and imparting a typical colour and flavour to the product.

Methods of curing. There are four methods of curing meats:

(a) ***Dry curing. Salt mixture is applied on the surface of meat and kept in chill room (2 - 4° C)*** for 7 - 10 days.

(b) ***Pickle curing. Meat is immersed in pickle solution (salt mixture dissolved in water) at 60 -*** 65° salinometer and stored in cold room (2 - 4°C) for 5 - 7 days.

(c) ***Injection brine. Pickle solution is prepared by dissolving salt mixture at 60 - 65°*** salinometer and the solution is then injected into meat and kept in chill room (2 - 4°C) for 5 – 7 days.

(d) ***Pickle injection and dry cover-***Meat is injected with pickle solution. This is followed by the application of dry salt mix on the surface of meat. The meat is kept at 2 - 4°C for 5 - 7 days.

Ham (thigh portion) and bacon (sides) and sausages of pig are the common cured meat products

Fermentation.

Fermentation is a simple low-tech and inexpensive method of preservation of foods that can be practiced at ambient temperatures. fermentation is a process in which chemical changes in an organic substrate are brought about through the action of enzymes liberated by microorganisms. During fermentation, microorganisms liberate lactic acid, volatile acids (such as acetic acid), antibiotics and bacteriocins that inhibit the growth of undesirable microorganisms and bring preservative effect in foods.

Microorganisms responsible for fermentation are lactic acid bacteria (LAB),certain molds and yeasts. LAB are one of the major groups of microorganisms responsible for fermentation of meat and meat products and for making silage of offals from fish, poultry and animals. The unique character of LAB is the production of lactic acid during fermentation.

Microorganisms in meat fermentation.

Bacteria	Lactic Acid Bacteria (LAB)	*Lactobacillus plantarum, L. sake, L. curvatus, Pediococcus acidilactici, P. pentosaceus, Lactococcus lactis*
	Micrococci	*Micrococcus varians*
	Staphylococci	*Staphylococcus carnosus, S. xylosus*
	Actinomycetes	*Streptomyces griseus*
	Enterobacteria	*Aeromonas spp.*
Yeasts	*Debaryomyce hansenii,*	*Candida famata*
Fungi	*Pencillium chrysogenum,*	*P. nalgiovense*

Fermentation process in meat and meat products. Physical, microbiological and biochemical changes take place during fermentation process.

These are-

(1) lactic acid production resulting in lowering of pH

(2) decrease in water activity (aw),

(3) inhibition of spoilage and pathogenic microorganisms,

(4) proteolytic enzymes breakdown muscle proteins (myofibrillar and sarcoplasmic proteins), salt soluble myofibrillar proteins gelify and provide firm consistency to the product and improve texture,

(5) development of aroma compounds and

(6) improvements in colour and nutritive value.

Irradiation-In 1980 the committee on the wholesomeness of irradiated foods concluded that "Irradiation of any food commodity upto an overall average dose of 10 Kgy (1mega rad = 1Mrad) causes no toxicological hazard; hence toxicological testing of food so treated is no longer required, and irradiation of food upto 10 KGy introduce no special microbiological and nutritional problems ". Irradiation is cold process. Radiation at low energy level does not induce radioactivity in the food constituents.

1. **Irradiation.** Irradiation is the controlled application of energy from ionizing radiations. Irradiation destroys the biological processes that are responsible for spoilage. It does not cause changes in freshness and texture of food. Irradiation produces very little chemical changes in food. None of the changes known to occur have been found to be harmful.

The sources of ionizing radiation are:

(a) Electrons produced commercially by linear accelerators at or below an energy level of 10MeV (million electron volts).

(b) Gamma rays from the radionuclides Cobalt 60 or Caesium 137 (the maximum energy of gamma radiation emitted is 1.3MeV and 0.66MeV, respectively). Radiation from a Cobalt 60 source is cheaper and has greater penetrating power than electrons. Gamma rays are commonly used for preservation of foods including meat and meat products.

(c) X – Rays are generated by machines operated at or below an energy level of 10MeV.

Units of radiation-

Radiation energy is measured in terms of rads.
Where : 1 rad = 100 ergs of energy absorbed in 1 g of matter.

A newly introduced standard irradiation (SI) unit is known as the Gray (Gy)
1 Gy = 100 rads   like 1metre = 100 cm ; 1 Krad = 1000 rads; 1 Mrad = 1,000,000 rads or 1000 Krad; 1 KGy = 1,000,000 rads.

Irradiation process. Irradiation processes are broadly divided into –
high dose (> 1Mrad) and
low dose (< 1Mrad) applications.

Radurisation.	**Radicidation**	***Radappertization (cold sterilization)***
low doses (< 1Mrad)	less than 1Mrad.	
pathogenic and spoilage microorganisms	viable, non-sporing pathogenic microorganisms 2 to 8 KGy could effectively eliminate these pathogens	It is similar to thermal processing of canned meat products. Very few microorganisms survive following the ionizing radiation process.
Enhance the keeping quality of meat and meat products.	Radicidation is also used to destroy or prevent reproduction of parasites	The doses used are in excess of 1Mrad (10 KGy - 45 KGy). The meat products can be kept at ambient temperatures for years with the application of radappertization without affecting palatability, nutritive quality and wholesomeness.

Radurisation is used along with refrigeration. The shelf-life of fresh meats in refrigeration (4°C) is normally 3 days. It has been demonstrated that the shelflife of radurised fresh meats is 5 weeks at 0 - 3°C	(tape worms – *Taenia solium and Taenia saginta; Trichinella spiralis) and the required dose is in the* range of 0.1 to 1 KGy.	The product is shelf-stable (long term storage without refrigeration). Products should be packed properly to prevent microbial recontamination and the deleterious effects developing on account of light, oxygen and moisture. Both metal containers and flexible packages are used under vacuum to prevent rancidity of the lipids.

Ability of irradiation to reduce nitrite in cured meats. The unique role of nitrite in meat

curing is colour fixation. It also imparts flavour to the product. More importantly, nitrite inhibits the growth of *Clostridium botulinum and provides protection against this organism.* Residual nitrite in cured meats forms nitrosamines that are carcinogenic. Radiation destroys *Clostridium botulium. Hence nitrite requirement in cured meats can be reduced by 50% if these* meats are subjected to radiation.

Chemicals.

Salt (sodium chloride). microorganisms, imparts flavour solubilizing the myofibrillar proteins	finished product containing about 2.5%.
Nitrate **Color** antimicrobial activity	The finished product should not contain more than 200 mg / lit of nitrite (due to nitrosamines, which are carcinogenic.)
Smoke. specific colour (brownish or mahogany) and preservative and antioxidant effects.	acids, phenols, carbonyls, alcohols and polycyclic hydrocarbons. Of these probably the most well known is benzpyrene because it is a carcinogen, so Liquid smoke
Sorbates **Lactate** **Organic acids -**Vinegar about	4% acetic acid, Lactic acid or acetic acid can be used at 1 or 2% level

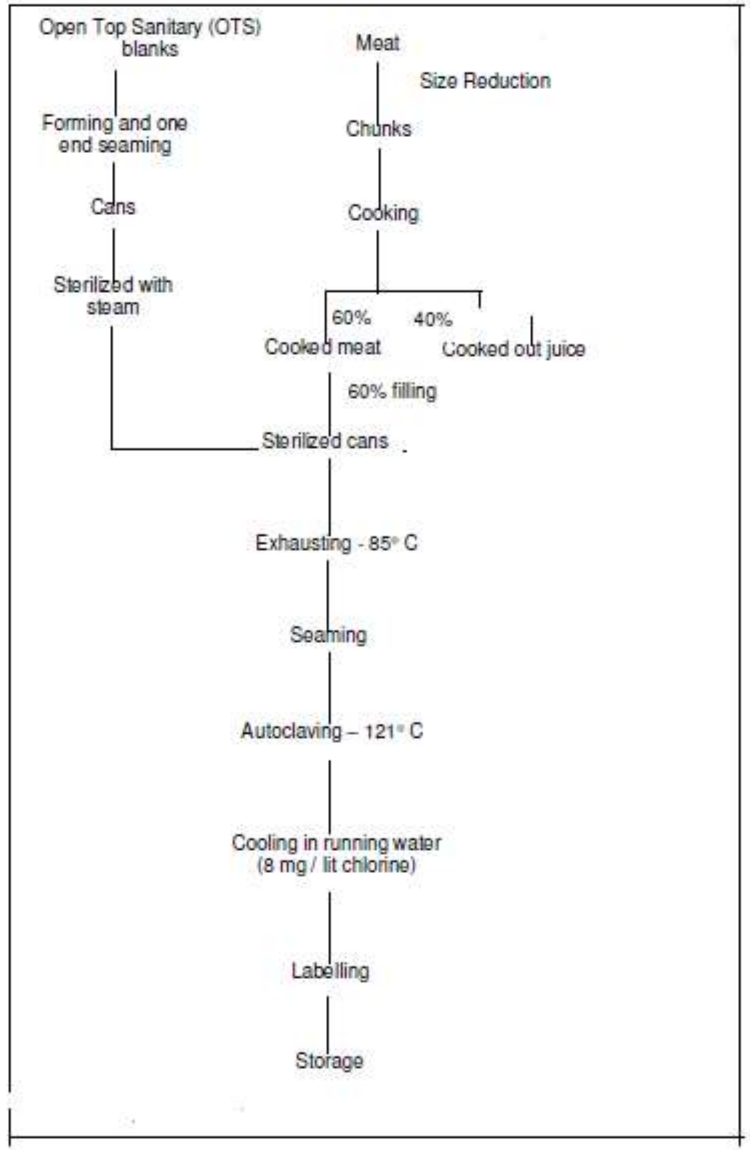
Thermal processing-

Canning of meat products

Containers- Steel base plate which is low in carbon, manganese, sulphur, phosphorous and silica is the starting material for fabrication of cans. This plate is rolled to the desired thickness. Tin coating is applied either by hot dipping or electrolytic plating. For meat, fish, poultry and other foods containing sulphurous compounds in appreciable amounts, tin cans are coated with sulphur resistant (SR) lacquer to prevent sulphur staining (purple or bluish) in can interior. Sulphur resistant lacquer is made of epoxyphenolic lacquer incorporated with
zinc oxide.

Process details-

Sterilized cans
Exhausting - 85° C
Seaming-can is sealed(seaming)
Autoclaving – 121° C, Normally the processing pressure is 15 psig equivalent to 121°C for a duration of 50 -60 minutes. After processing, the cans are cooled in running water-containing chlorine (8 mg/ lit).
Labelling
Storage



Open Top Sanitary (OTS) blanks
Meat
Size Reduction
Forming and one end seaming
Chunks
Cans
Cooking
Sterilized with steam
60%
40%
Cooked meat
Cooked out juice
60% filling
Sterilized cans
Exhausting - 85° C
Seaming
Autoclaving – 121° C
Cooling in running water (8 mg / lit chlorine)
Labelling
Storage

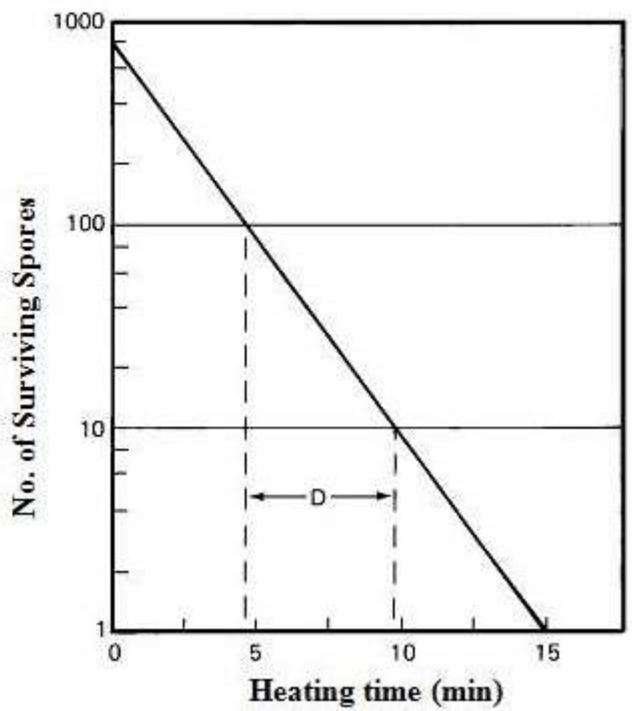
Labelling. The label should contain all the details about the date of manufacture, batch no., net weight, ingredients, legal declaration about whether they confirm to GRAS (Generally Regarded As Safe), wholesale price, retail price, *etc..*

Storage. Conveyed to godowns for storage and distribution.

Standards. The product should conform to the standards laid down by regulatory agencies

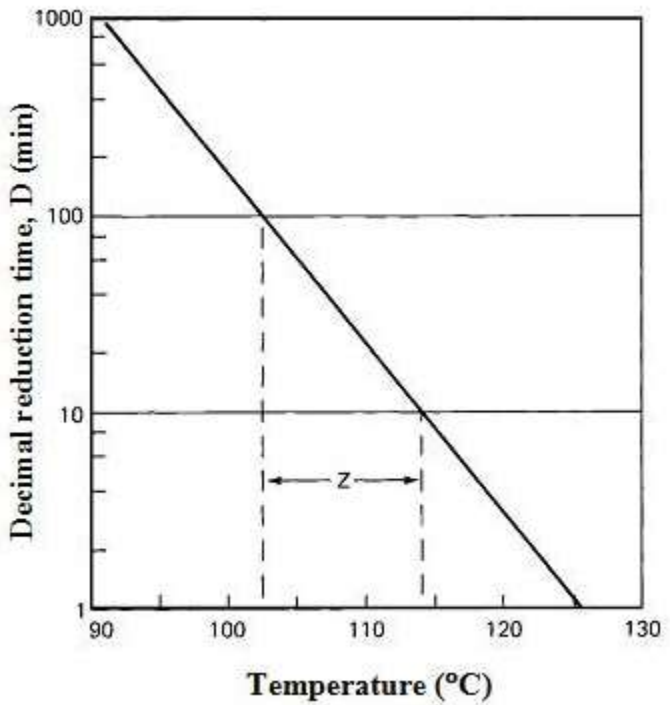
regarding drained weight (weight of the solid content remained after removing the liquid portion from the can), vacuum and microbiological standards.

The rate of destruction is a first-order reaction; that is when food is heated to a temperature that is high enough to destroy contaminating microorganisms, the same percentage die in a given time interval regardless of the number present initially. This is known as the logarithmic order of death and is described by ***thermal death rate*** **curve** .



The time needed to destroy 90% of the microorganisms (to reduce their numbers by a factor of 10) is referred to as the **decimal reduction time** or ***D-value***. D-values differ for different microbial species and a higher D-value indicates greater resistance.

The thermal destruction of microorganisms is temperature dependent and cells die more rapidly at higher temperature. By collating D-values at different temperatures, a *thermal death time* (TDT) curve is constructed .



The thermal death time or ***F-value*** is used as a basis for comparing heat sterilization procedures.

F-value is the time required to achieve a specified reduction in microbial numbers at a given temperature and it represents the total time-temperature combination received by a food.

The slope of the TDT curve is termed the ***z-value*** and is defined as the number of degrees Celsius required to bring about a 10-fold change in decimal reduction time. F-value is quoted with suffixes indicating the retort temperature and the z value of the target microorganism.

For example, a process operating at 110 ◦C based on a microorganism with a z-value of 10◦C would be expressed as F^{10}_{110}. Hence, D-value and z-value are used to characterize the heat resistance of a microorganism and its temperature dependence, respectively while F-value is used for comparing sterilizing procedures.

Hurdle technology

Hurdle technology (HT) is a new concept in the preservation of meat and meat products. A combination hurdles (heat, refrigeration, preservatives, aw, irradiation, fermentation and packaging) is applied to inhibit the growth of microorganisms. Two or more hurdles are preferably used in the system. Intermediate moisture meats and fermented sausages are some of the examples where HT is used.

Thank you