Lecture – 003

MEAT PRESERVATION TECHNIQUES

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Introduction

Fresh meat must be considered as one of more perishable foods. Preservation measures must be applied promptly after slaughter. Meat preservation involves application of measures to delay or prevent certain changes which make meat unusable as a food or which downgrade some quality aspect of it.

The pathways by which such deteriorations car occurs are diverse and include microbiological, chemical and physical processes. There are numerous methods of meat preservation and all of them have the same aim: to kill and/or inhibit the growth of the predominant spoilage microorganisms on and in meat or meat product.

It is obvious that in evaluating a method of preservation, criteria other than that of prevention of spoilage must be considered. Also attention must be given to:

1. The effect of the method on product quality
2. Any health hazards involved for either the food handler or the consumer
3. Possible misuse of the method
4. Distribution and marketing problems
5. Engineering and economic evaluation of the method's commercial application

1. Meat curing.

It is an important food preservation system that combines salting to selectively control microorganism and fermentation to stabilize treated products. Salt was used in ancient times, as a preservative method based on reducing water activity to unfavorable lever for microbial growth.

1.1. Ingredients used in meat curing

1.1.1. Salt (1.8 – 2.2 %)

The salt has the following functions:

- Preservative: like Sodium Ascorbate (use 300 ppm)
- Contribute to Flavor
- Solubilization of proteins (extraction of protein) It also gives form and fimness of the product.

1.1.2. Sugar

It has the following functions:

- Flavour
- Contreracts harshness of salt
- Energy for bacteria that change NO_3 to NO_2.

1.1.3. Nitrite or Nitrate

The most used is that Na at a lever of 100 –300 ppm

- Contribute to flavor and prevents warmed-over flavor. Reaction between Nitrite and myoglobine leads to added flavor to the final product.
- Inhibit lipid oxidation by stabilizing fats thereby preventing oxidative rancidity
- Color: Cured-pink or bright red color (attractive). Nitrite is reduced to Nitrous oxides, which reacts with myoglobin to produce the desired red colour (Nitrosomyoglobine).
- Anti-botulinal effect: It is bacteriostatic i.e inhibits grouth of bacteria especially *Clostridium botulinum*. This is by lowering the Water activity.

1.2. Curing methods

There two (02) methods used in meat curing: the dry and wet curing.

1.2.1. Dry curing

The oldest way of curing meats. Curing ingredients are rubbed on the surface of the meat to be cured. The curing mix contains salt, sweetener, nitrites and seasonings like spices, herbs, etc. this method is used in sausages and other meat products.

1.2.2. Wet curing

The ingredients in this method are disserved in water to form brine cure. Wet curing can be done by:

- **Pumping**: Involves injecting the brine into the meat This is a more rapid method of curing and ensures complete penetration of curing ingredients.
- **Stitch pumping**: A long needle with multiple holes around the shaft is used. Needle is inserted into meat and the curing solution is pumped into the product. This is done in other cuts like bacon.

- **Artery injection**: A large needle with only one hole in it is inserted into in the brachial or femoral artery and the cure solution is injected into the arterial system. This is done to cuts like hams, briskets, tongues which have an intact vascular system.
- **Needle injection**: A machine with multiple needles that injects automatically, meat cuts with the curing solution. This is the most common way today.
- **Soaking:** in this case the meat is soaked in the brine.

1.3. Curing Advantages

The main curing advantages are following:

- Curing especially wet adds weight to the meat and hence realizes a higher profit.
- Cured meat products have been found by some people to have eating quality as good better than those processed to original weight.
- Cured meat products are also more tender, juicy and better in flavor.

2. Meat smoking

Meat smoking is done by combustion of moist sawdust (hardwood) or the use of liquid smoke.

2.1. Purpose of meat smoking

- Meat preservation in order extend its shelf life:
    - Smoking at high temperature cooks the meat and this destroy the bacteria and enzymes
    - Some chemical components of the smoke contribute to make the medium unfavorable for the growth of microorganisms.
- For taste, to improve flavor by ephenolic compounds and droplets.
- Development of color: results of interaction of carbonyl groups with animal proteins. Phenol is also to contribute to color. There are thee determinants of color formation by smoking:
    - Moisture level: at 6-10 % on the surface or in the surface layers of meat, allows better absorption of smoke.

    - Temperature: Smoke temperature should be kept low to prevent excessive drying.
    - Concentration of smoke: This is related to deposition or penetration of smoke.
- Protection from oxidation.
- Smoking eases attraction between the casing and muscle. Its eases the removal of casing in sausages (natural cellulose casing is used). In this case, the acid component of smoke permits the surface protein coagulation thereby forming a very smooth skin. It penetrates a few into product, this eases pealing of casings.
- Smoke impacts textural changes, through the loss of solubility of myofibrillar protein and by cross linking of surface proteins.

2.2. Preservative value of smoke

The smoke produced from burning wood contains a number of compounds. The compounds and composition vary with the type of wood and the ventilation o fire. Wood smoke consists of gases, vapors and droplets. The vapors which can not be seen by the naked eye contribute to the smell characteristics. Vapors consist of Valeric aldehyde, Furans and phenols (produced from lignin, a substance found in the cell wall of the wood).

These are examples of gases: Carbone dioxide, Carbon monoxide, Hydrogen, Hydrocarbons.

2.3. Smoking methods

There three methods used in meat smoking: Hot smoking, Cold smoking and liquid smoking.

- **Hot smoking**: This method involves temperatures >80 C and the meat is cooked during processing. This method is commonly used for smoked sausages.
- **Cold smoking**: This involves the temperature between 30 and 40C and the product is not cooked. Cold smoking is used for flavor and is more common in industrialized countries.
- **Liquid smoking**: It is when the smoke is passed in a liquid and later the meat is plunged in the liquid in order to absorb the smoke.

4. Refrigeration and freezing

Both are low temperature preservation methods, the first using positive cold and the second, negative cold. Low temperature preservation is important as most of microorganisms causing spoilage of fresh meat, poultry and eggs have optimum temperatures for growth at 20 to 35C. To obtain the maximum refrigerated of these foods, microorganisms which grow best at room temperature as well as those can also grow at refrigeration temperatures must be controlled.
This general observation also conveys insight into potential sources of contamination and what to expect from sanitation practices and refrigeration of the environment and processing equipment. While psychrotrophs like *pseudomonas* are major causes of spoilage for most fresh meats, poultry and eggs.

4.1. Refrigeration

Refrigeration is done for meat intended for short term preservation (some days) especially by fresh meat retailers. Refrigeration is done in order to:

- To reduce bacterial growth
- To slow down enzymatic changes
- To aids processing (sausage processing)

The following points should be taken in consideration while refrigeration

- Refrigeration should be done after rigor mortis in order to prevent the cold shortening of carcasses mainly in beef and lamb.
- Refrigeration should e done at positives temperatures as low as possible. However different carcasses require refrigeration temperatures. Refrigeration is done at temperatures just above 0C.

There are some examples of refrigeration temperatures:

- Pork carcasses in chilling room at 0°C , the carcass will get to 0-4 within 24 hours
- Poultry carcass, the temperature reaches 5C or less in less than 8 hours
- Fresh retail cuts kept at temperatures just above 0C it will keep for 6 -7 days.

Table 1. Storage time at 4° C of some beef refrigerated products

Product	Storage time (days)
Fresh roast, steaks, chops, ribs	3-5
Home cooked beef, soups, stews or casseroles	3-4
Fresh beef liver or variety meats	1-2

4.2. Freezing

Freezing is done for meat intended for long term preservation. It involves subjecting the meat and meat product to temperatures below 0°C. This normally impacts the following effects:

- Freeze burn: Is due to dehydration of the exposed surfaces, consequence of sublimation of ice to vapor. It is common in chicken.
- Freezing impacts flavor changes, oxidation and nutrient changes (unsaturated fats may go rancidic).

The freezing point of meats is between -1.5 and -3°C. Beef and fish (-1.7 to -2.2C), lamb and veal at – 2.8°C.

4.2.1. General consideration in meat freezing

The following points should be taken in consideration while refrigeration

- Meat has to be frozen after complete rigor mortis and sufficiently aged as meat does not continue to tenderize while frozen.
- Meat should be well trimmed because fat can become rancid on long storage
- The end of bones that may pierce the wrap should be shield with foil or plastic before packaging.
- Frozen large cuts will keep better and longer, with less flavor changes, that frozen smaller cuts, thin slices or mince.
- Temperature fluctuation: It is important to make sure temperature doesn’t fluctuate by more than 0.5C. Big temperature changes can mean a partial thaw which damages the structure of meat.

4.2.2. Factors affecting meat while freezing

Various factors affect meat or meat product under frozen condition. Principles are following:

- Time and conditions of frozen storage:
    - Time is determined by the amount of oxidation that occurs(the more oxidation that is possible)
    - Condition of frozen storage will depends on freezer temperature. If the temperature is at -18C, there is a minimal growth of microorganisms and less oxidation. At -10C bacteria stop growing and chemical reactions slow down.
- Temperatures fluctuation. It increases the thaw drip. The tempeature fluctuation causes ice crystal growth. Above -18C, small ice crystals which are less stable tha large than large ones, are formed and water migrate to from large ones. We get a recrystallization and growth of ice crystals thus increase in thaw drip.

- Quantity and type of wrapping material. PVC is the best material to use under frozen conditions because it has good moisture and vapor barrier which reduces oxidation. Wax coated papers which allow O2 transmiosssion may also be used. During freezing, the meat keeps in bright color but some oxidation might take place, which leads to off flavors. The packaging material used in frozen conditions has to be:
    - Strong when wet
    - Light fittering and odorless
    - Resistant to tear and punctures
    - Impermeable to odors.
- Type of product. A product with a lot of unsaturated fat is less stable than those with a lot of saturated fat, under frozen temperatures.

- Methods of processing:
    - Salt addition increases rancidity thus season meat products should not br frozen.
    - Cooked or smoked meats also develop warm off flavor when frozen. Oxidation is related to the degree of cooking before freezing and increases with cooking time.

4.2.3. Methods of freezing

- **Still air freezing:** Commercially, air is used to cool products at -10C to -30C in suitable freezing room. Products remain in the freezing chamber until frozen. This method is the slowest and cheapest. Its heat transfer is medium or poor conduction. (For home freezer temperature are -12C).
- **Plate Freezing:** The product is placed on surface of plate which contains the coolant. Heat transfer is good conduction because the metal is the transferring medium. The metal thickness should be controlled to improve heat conduction.
- **Cold air blasts:** Air with relatively high speed is blown in the room. Air is used like a medium of heat transfer. This is used in large industries. Temperature reaches -10 to -40C. This method is also called Sharp frozen or Blast frozen method.
- **Liquid immersion freezing/Liquid sprays:** In this case, products are placed and passed through liquid or sprays. The liquids mostly used are brine, glycerol and glycols. After immersion, water is used to rinse the product when taken out.
- **Cyanogenic freezing:** Here liquid gases are used like CO2, Nitrogen, and Nitrous Oxide. In most cases liquid or vapour N2 is used. Temperature is usually -19.5C. Liquid CO2 under high pressure can also be used.

5. Heat preservation

The meat and meat product undergo heat treatment at a certain temperature for a determined time after being put in a sealed container (Canning). Two types of heat are generally applied: Pasteurization and sterilization.

5.1. Pasteurization

Pasteurization uses temperature below 100C and sufficient to destroy pathogenic microorganisms, spores but heat resistant spoilage microorganisms survive.

5.2. Sterilization

This method of heat preservation uses temperatures above 100 C. It is mainly used for canned products. During canning of minced meat, heat is transferred by conduction and convection. Canning reduces the water activity and destruct most pathogens and spoilage microorganisms; which extends the shelf life of the product.

The extent of bacterial inactivation depends on:

- Number and kind of microorganisms
- Heat resistance of the microorganism
- Environment around microorganism (pH, salt, Water activity, temperature etc.).

Most spore formers (*Clostridium, Bacillus*) are heat resistant compared to non spore forming microorganisms (*Micrococcus, Pseudomonas, Enterobateriaceae...)* and Gram negatives are more heat resistant than gram negatives. The two reference bacteria for sterilization are *Clostridium botulinum* and *Clostridium sporogenes* due to their ability to grow in absence of air and form spores. Their spore can survive heat and chemicals and start growing later on normal storage temperature.

The appropriate temperature and time needed to sterilize a container filled with the product depends on the nature of product in term of its composition, pH and Water activity.

- pH influence the intensity of heat treatment required for preservation. The lower pH, the minor heat treatment applied. There are three groups of foods according to their pH values:
    - **Low acid foods (pH > 4.5)** e.g. canned milk, fish, meat and vegetable products. These require high heat to eliminate vegetative microorganisms and their spores. Jellied meat pH 4.5; Luncheon meat (6.2) and Blood sausages (7.1).
    - **Acid foods (pH 4.0 – 4.5)** : Canned fruits, sour fish, sour products
    - **High acid foods (pH < 4.0)**: Canned fruits juices, jams and fruits.

  Both of them require mild heat treatment. Spores of *Clostridium botulinnum* can not germinate or grow in the product whose the pH is below 4.8.

- Water activity is not the total amount of water (but its availability) that influences growth of microorganisms. Some ingredients like sugar, salt, starch, milk proteins are added in the product to compete with microorganisms for available water in the product. They bind water. Bacteria require an a_w of > 0.90; Yeasts > 0.88; and moulds >0.75 for their growth. *Clostridium botulinum* is inhibited at an a_w below 0.93.

6. Drying

Drying meat under natural temperatures, humidity and circulation of the air, including direct influence of sun rays, is the oldest method of meat preservation. It consists of a gradual dehydration of pieces of meat cut to a specific uniform shape that permits the equal and simultaneous drying of whole batches of meat.

Warm, dry air of a low humidity of about 30 per cent and relatively small temperature differences between day and night are optimal conditions for meat drying. However meat drying can also be carried out with good results under less favorable circumstances when basic hygienic and technological rules are observed.

Intensity and duration of the drying process depend on air temperature, humidity and air circulation. Drying will be faster under high temperatures, low humidity and intensive air circulation. Meat drying is a complex process with many important stapes, starting from the slaughtering of the animal, carcass trimming, and selection of the raw material, proper cutting and pre treatment of the pieces to be dried and proper arrangement of drying facilities. In addition, the influence of unfavorable weather conditions must also be considered to avoid quality problems and production looses. The secret of correct meat drying lies in maintaining a balance between water evaporation on the meat surface and migration of water from deeper layers.

The process of meat drying can be summarized as following;

- Cut meat strip
- Smear salt (dip into brine solution for 5 minutes)
- Remove and hang in an air circulation ranks. Salt prevent microorganism’s growth and insect attack. This should be done 5 hours after slaughter.
- Drying takes 4 to 5 days.

A well dried meat product must have the following quality characteristics:

- A uniform appearance
- Absence of large wrinkles
- Uniform dark red color of surface and a bright red color in center (after cross section).
- The texture consistence should be hard, similar to frozen meat
- Free of off odors.

7. Acidulation

Acidulation of meat consists in increasing acidity of meat. It accomplishes its preservative effect by creating an environment within the product which retards the growth of spoilage and food poisoning organisms. This method of preservation is used in Dry sausages. There are two (02) general methods which are utilized to achieve acidulation, fermentation with microorganisms and chemical acidulation.

7.1. Fermentation

The fermentation of meat product is generally accomplished through the addition of lactic acid producing organisms into the meat with an adequate Carbone source, usually Dextrose, to facilitate acid production given appropriate condition and humidity. Various species of lactic acid bacteria including *Pediococcus* and *Lactobacillus* species are used. They are often used in combination with othe microorganism, *eg Micrococcus varians* wich produce other desirable changes in the product. Prior to fermentation, the product will normally have a typical meat pH in the range of 5.8-6.0. By controlling the quantity of fermentable carbohydrate available, one can control the ultimate pH of the system.

7.1. Chemical Acidulation

Due to the lengthy time required for bacterial fermentation of meats and the obvious of this method, the use of chemicals, primarily organic acids, has become common. This method results in essentially the same end as bacterial fermentation while reducing the time required to achieve the end result and therefore substantially reducing the related costs of production. The most widely used chemical acidulant in meat products is Glucono-Delta-Lactone (GDL). This substance hydrolyzes in meat system to produce gluconic acid and therefore results in a decreased pH.

8. Other Methods of preservation

- **Freeze drying**

  Its produces better product. Water in form of Ice is removed by sublimation (under vacuum). The meat remains frozen throughout the drying process. The moisture content

is reduced to less than 2% and the product is porous and easy to rehydrate. The Freeze drying has the following disadvantages:

- Retains enzymatic activity
- Rancidity, Browning (non enzymatic) and protein denaturation
- Bacterial spores, moulds, yeast may survive.

- **Irradiation**

  By use of strong radiations including:

  - Ionizing: Beta, X-rays or Gamma- rays
  - Non-ionizing: UV, Infrared, Microwaves.

  Three methods can be used.

  - **Radapperisation** (more suitable): It is equivalent to sterilization.
  - **Radicidation** : Equivalent to pasteurization with respect to pathogenic microorganisms
  - **Radurisation**: Equivalent to pasteurization with respect to spoilage microorganisms.

Table 2. Experimentally determined MRD[1] for selected radappertized meats

Meat	Irradiation Temp.(0C)	MRD (kGy)
Bacon	5 to 25	25
Beef	-30+/-10	41
Ham	5 to 25	31
Ham	-30+/-10	33
Pork	5 to 25	43
Corned Beef	-30+/-10	24
Pork Sausage	-30+/-10	27

[1] MRD: minimum radiation doses

Further Reading

1. Arnau, J. et al., 2007. Technologies to shorten the drying period of dry-cured meat products. *Meat Science*, 77(1 SPEC. ISS.), pp.81–89.

2. Chen, J.H. et al., 2012. Intervention Technologies for Ensuring Microbiological Safety of Meat: Current and Future Trends. *Comprehensive Reviews in Food Science and Food Safety*, 11, pp.119–132.

3. Dave, D. & Ghaly, A.E., 2011. Meat Spoilage Mechanisms and Preservation Techniques : A Critical Review. *American Journal of Agricultural and Biological Sciences*, 6(4), pp.486–510.

4. James, C. et al., 2007. Decontamination of poultry carcasses using steam or hot water in combination with rapid cooling, chilling or freezing of carcass surfaces. *International Journal of Food Microbiology*, 114(2), pp.195–203.

5. Koohmaraie, M. et al., 2005. Post-harvest interventions to reduce/eliminate pathogens in beef. *Meat science*, 71(1), pp.79–91.

6. Nychas, G.-J.E. et al., 2008. Meat spoilage during distribution. *Meat science*, 78(1–2), pp.77–89.

7. Savell, J.W., Mueller, S.L. & Baird, B.E., 2005. The chilling of carcasses. *Meat Science*, 70, pp.449–459.