PRESERVATION OF MEAT: THERMAL PROCESSING

NS Mahendrakar

Fresh meat is low acid (pH > 4.5) food and requires heat treatment for preservation. Thermal processing is the application of heat energy to inactivate pathogens and spoilage microorganisms to produce shelf stable product. Canning is general term applied to thermal processing. Canning of meat provides safe products which have desirable flavor, texture and appearance. Heating also stops undesirable changes by inactivating endogenous enzymes. Two temperature regimes, Pasteurization and Sterilization, are used. Pasteurization refers to moderate heating in the temperature range of 58 – 75 ºC whereby most of the microorganisms are killed or inactivated. This is also the cooking temperature range of most processed meats. Pasteurization extends the shelf life of meat although such products need to be stored under refrigeration. Sterilization refers to severe heating at a temperature above 100 ºC whereby all microorganisms are killed or their microbial cells are damaged beyond repair. This heat treatment renders the meat products commercially sterile though some bacterial spores may survive. Exposure of meat to such high temperature imparts sulphydryl flavor and noticeable changes in texture and color. The water and fat contents and consistency determine the thermal processing schedule. Moist heat is more effective in killing microorganisms and spores as compared to dry heat.

The following aspects are covered in this topic:

1. Principles of thermal processing

2. Canning

3. Retort pouch processing

4. Thermal dehydration

1. PRINCIPLES OF THERMAL PROCESSING

The heat required to sterilize a meat product depends upon the types and number of microorganisms present and the nature of the meat product. Heating of food and penetration of heat in to food is important for thermal processing. Steam is the source of heating in canning. Moist heat is more severe than dry heat of same temperature. The factors determining heat penetration are:

i. Size and shape of the container – larger the container longer the time needed
ii. Material of container – glass has slower rate of heating than the metal cans
iii. Initial temperature of food – high initial temperature is important for canning slow heating foods like meat
iv. Rotation and agitation – agitation of container hastens the heat penetration.

Heat transfer: Heat transfer in cans occurs due to the differences in temperature between two objects. Heat transfer takes place by conduction and convection.

Conduction: Transfer of heat takes place through the particles and distributes the temperature throughout. Heat is transferred directly from particle to particle and no other medium is involved. When large meat piece is heated, the heat is transferred from surface to the center.

Convection: Transfer of heat through fluid media is by mass movement of particles in the medium such as water.

Heating increases pH and reduces enzyme activity. All enzymes are destroyed at 79 ºC in a few minutes. Heating causes denaturation of proteins and loss of water. Nutritionally cooking improves the digestibility of meat but it changes amino acid composition. Some vitamins and minerals are also lost during heating. Warmed over flavor results when cooked meat is refrigerated and reheated. Warmed over flavor is an unpleasant characteristic as odors and flavors are described as stale, cardboard - like, painty or rancid.

Denaturation is a process in which proteins or nucleic acids lose the quaternary, tertiary and secondary structure. Application of strong acid or base, a concentrated inorganic salt, an organic solvent (alcohol or chloroform), radiation or heat cause protein denaturation. Denaturation affects functional properties of proteins adversely.

Cooking reduces bacterial growth by reducing water activity. Water activity (a_w) is defined as the ratio of the vapor pressure of water in a material to the vapor pressure of pure water at the same temperature. It is expressed as:

a_w = Vapor pressure of water in food / Vapor pressure of pure water at the same temperature

2. CANNING

Canning is a process of preserving food by sterilization and cooking in a sealed metal can. This will destroy bacteria and protects from recontamination. In bottling, the foods are sterilized and cooked in glass jars, which are closed with sealed lids. Canned foods are also known as tinned foods, because the cans are made of tin – plated steel.

The main considerations regarding canning of meat and meat products are:

Types of can: Five types of cans used in the meat industry are:

Square and Pullman base: These containers are used for pasteurized meat. Chopped products such as spiced luncheon meat, chopped ham and corned beef are packed in such cans.

Pear shaped: These cans are used to pack pasteurized hams. These are also a type of Pullman base containers.

Round sanitary: Cylindrical or round sanitary cans are available in a variety of diameters and heights to meet the requirements of canned meat products.

Drawn aluminum: Aluminum cans are used for sausages and meat spreads.

Oblong: Oblong cans are used for sterile canned meats. Luncheon meat cans are available in either tin plate or aluminum.

Can material: Tin plate cans are made of thin sheet of steel coated with a very thin film of tin. The tin coating covers the surface of the steel to prevent rusting.

To prevent interaction between meat and the metal, cans are generally coated on the inside with an organic material. The enamel and lacquer are used with organic coating. These coatings are solutions of resins in organic solvents. Acid - resistant and sulfur - resistant organic coatings are used in food industry. Acid - resistant coated cans are used primarily for fruits. Sulfur - resistant cans are used for meat products This is necessary because during the retorting operation, sulfur released from meat proteins will stain tin plate and blacken.

Aluminum or coated aluminum cans are developed to replace expensive tin cans. Aluminum cans are light in weight and free from rusting but they lack strength.

Thermal processing: The purpose of meat canning is to provide safe product. Sterilization of meat is done to kill all microbes and spores. To establish a suitable processing schedule, it is necessary to estimate the heat required to destroy the most resistant spoilage or toxigenic microbial spores. Heat treatment at 121 ºC for 15 minutes sterilizes the food. Simply heating a can at 121 ºC in pressure cooker or retort will not destroy all microorganisms. Heat transfer through the food in can is slow and hence requires heating for several hours. The heat processing efficiency is measured from the survival of *Clostridium botulinum* spores.

The time required to destroy these spores, under specific conditions, is determined at different temperatures. The heat resistance of microorganisms is expressed in terms of their thermal death time (TDT). The TDT (also designed as F_0) is defined as the time it takes at a certain temperature to kill a stated number of organisms or spores at 121 °C. The TDT of *Cl. botulinum* is 2.5 minutes at 121 °C. Meat products given this amount of heat are safe from botulinum hazard. Other organisms, which have a heat resistance greater than *Cl. botulinum*, are likely to be present and if not inactivated, the product spoils. For this reason, many canned cured meats are heated to provide F_0 values of 3 and non - cured meats of 6.

Retorts: The most important phase of a sterile canning operation is retorting. The retort operation serves two purposes: (i) Products are subjected to a high temperature for sufficient duration to destroy all organisms and (ii) Products are cooked so that they can be eaten directly.

A retort is a steel tank in which crates or baskets containing the cans are placed for cooking and cooling. It is fitted with a door, which can be closed to provide a seal to hold the cooking, or cooling pressure. Most canned meat products are cooked in a non - agitating type of retorts. These retorts are closed - pressure vessels that operate in excess of atmospheric pressure for cooking. The steam comes from steam boiler or generator.

Commercial sterility: In commercial canning practice, total sterility is not achieved. Some bacteria can form spores, which need very severe heating to kill. Such severe heating reduces the eating quality of meat. Hence a relatively mild process is developed termed as "Commercially sterile" for shelf stability and for long time storage at room temperature. Commercial sterility is a practice in canning industry wherein heating is just sufficient to destroy or inactivate all pathogenic, toxigenic and spoilage organisms. This kind of product may contain a few numbers of heat resistant spores, but normally they will not multiply. Commercially sterile meat products have a shelf life of two years or more at room temperature.

Aseptic canning: Foods are pre - sterilized at a very high temperature (150 – 175 ºC) for a few seconds and then sealed in to cans under aseptic conditions. The flavor, color and retention of vitamins are superior with this high temperature - short time process to the conventional canning.

Canning process: For canning only deboned meat is used. The deboned meat is partially cooked. The cooked out juice is used for brine (2.5 %) or for curry preparation. The cooked meat and brine are hot filled in cans. The filled cans are exhausted for 20 minutes so that the cold point of can gets a heat treatment up to 80 °C. Exhausting also removes the air bubbles from the can. After exhausting, the cans are immediately sealed. The sealed cans are processed at 121 °C for 1 h and then cooled in water tank (Fig. 1). Cooling avoids over cooking. After cooling the cans are wiped to remove the surface water adhering to the cans. This avoids rusting. Finally the cans are labeled and stored.

Cold point: Cold point is the location in the can where heating is slowest. The position of the cold point is determined by the type of food material, its heat transfer mechanism, and by the agitation of can in the retort. When convection heating is the main mechanism involved, the cold point is on the vertical axis, close to the bottom end of the can. In conduction heating, the cold point is located in the geometrical center of the container. For viscous meat material, with cans rotating during heating, the cold point is close to the geometric center. In static heating of meat pieces in brine, where the leading heat transfer mechanism is convection, the cold point is one – third from the can bottom end.

3. RETORT POUCH PROCESSING

Retort pouch products are also called as "Heat and Eat" food products. Food is packed in flexible material, sealed and sterilized at 121 ºC. This makes the product shelf stable like canned foods. Filling should be accurate and there should not be contamination of sealing area. Head space should be removed before sealing to prevent bursting during retorting due to increased pressure inside. The head space interferes in uniform heat transfer. Quick heat penetration helps in better quality retention. Retort pouch products are processed to commercial sterility and are shelf stable without refrigeration.

Retort: Different kinds of retorts are used for pouch processing. Non – agitating and still retort either vertical or horizontal type is widely used retort. Vertical retorts handle more number of pouches per unit retort volume. They require less floor space and hence are more efficient than horizontal retorts. Continuous agitating of pouches while processing needs less processing time.

Retortable pouches: Retort pouches are light, convenient and useful for defense personnel. Sterilizable flexi – bags are newer developments, which reduce damage on meat. These are sealed multilayer laminates with or without aluminum foil. They are heat resistant plastics suitable for thermal processing at 121 ºC. They are heat sealable with good barrier properties. They reduce the processing time by 30 – 35 % and minimize quality damage. They have long shelf life and very convenient for processing, transportation and serving. In India the 3 – ply laminate of PET / Al foil / PP is commonly used. Retort processing schedule depends on F_0 value and needs to be arrived at based on product quality as done for canning of foods (Fig. 2).

The main limitations of retort pouch processing are: (i) Major capital investment, (ii) Filling is slower and needs skilled personnel and (iii) Detection of leakage in flexi - pouch is more difficult.

4. THERMAL DEHYDRATION

Thermal dehydration of meat is also a method of preservation. It can be achieved by the removal of water from meat by evaporation. Drying may be combined with salting and smoking resulting in to intermediate moisture products like ham, bacon and sausage. Such approach of combined treatments enhances the sensory characteristics of the end products.

Principles of meat drying: Dehydration reduces water activity (a_w) thereby hinder microbial growth and biochemical reactions. Water content of raw meat is in the range of 75 – 80 % (a_w = 0.98). This is reduced to the safe value of 12 – 15 % when drying is the sole preservation process, and to 28 – 50 % (a_w = 0.7 – 0.75) when drying is combined with salting. Temperature, relative humidity and velocity of hot air, size, structure and proximate composition of the product determine the drying time needed to reach the safe water content and a_w. Heat transfer from hot air to the material and water transfer in the reverse direction are involved in drying of the material. Evaporation of water from the product surface is accompanied by migration of water inside the product toward the surface.

Fresh or chilled meat can be subjected to drying directly. Frozen meat must be thawed by tempering the meat at chill temperatures prior to drying. Preparation of drying of meat consists of cutting the carcass in to primary or retail cuts and trimming to remove undesirable materials (damaged tissues, extra fat, connective tissue, bones). Meat is then cut in to strips or flat pieces for direct air drying or may be salted or spiced before drying.

Dried products and product quality: The dried meat and meat products include (a) directly dried, (b) salted and dried, (c) salted, dried and smoked and (d) salted, fermented and dried. The water content of these products is in the range of 8 – 63 %, a_w in the range of 0.4 – 0.95 and salt content in the range of 0.5 - 12%.

Decrease in water and a_w values affect biochemical reactions occurring in meat. High temperature drying will affect cooking while moderate temperature drying favors fermentative reactions. As drying proceeds, microbial proliferation slows down and eventually stops when the minimum a_w for growth is reached. Microbial enzymes help develop the acidic pH (fermentation of sugars in to lactic acid), color and flavor (conversion of nitrate in to nitrite) of cured meat products.

Removal of water and dripping away of molten fat during hot air drying reduce mass yield. Volume shrinkage of meat also causes wrinkled appearance and a hardened texture. Water loss automatically results in increase of nutrient (fat, protein and minerals) contents. Lean meat color changes from red to brown during drying.

Biochemical, physico - chemical and microbiological changes occur during storage of dried meat. The extent of change depends on a_w, pH, type of packaging and storage conditions (temperature and relative humidity of air). Chemical deterioration is caused by lipid oxidation imparting rancid flavor and odor in meat. Vacuum packing of dried meat removes oxygen and thus reduces oxidative rancidity.

CONCLUSION

Thermal processing is the application of heat energy to meat to inactivate pathogens and spoilage microorganisms to produce shelf stable product. Canning is general term applied to thermal processing. Heating also stops undesirable changes by inactivating endogenous enzymes. Water and fat contents and consistency have bearing on the thermal processing schedule. Moist heat is much more effective in killing microorganisms and spores as compared to dry heat.

Cooking, canning and retort pouch processing are the common thermal processing practices for meat and meat products. Canning and retort pouch processing allow storing or transporting meat in environments where no other preservation method is successful. The aim of thermal processing is to destroy the vegetative cells, spores and enzymes responsible for deterioration of meat. Thermal processing schedules are dependent on time – temperature required to destroy mainly the pathogen *Clostridium botulinum.* Retort pouch processing is becoming more popular due to advantages such as low cost of flexi - packing material, less time and cost of processing, lower weight of the packed product and easy for transportation and serving.

Thermal dehydration is one of the methods of meat preservation where water of meat is removed by evaporation by application of heat. Dehydration reduces water activity (a_w) thereby hinder microbial growth and biochemical reactions. Lipid oxidation imparts rancid flavor and odor in meat during storage of dried meat and meat products. Vacuum packing of dried meat removes oxygen, thus reducing rancidity.

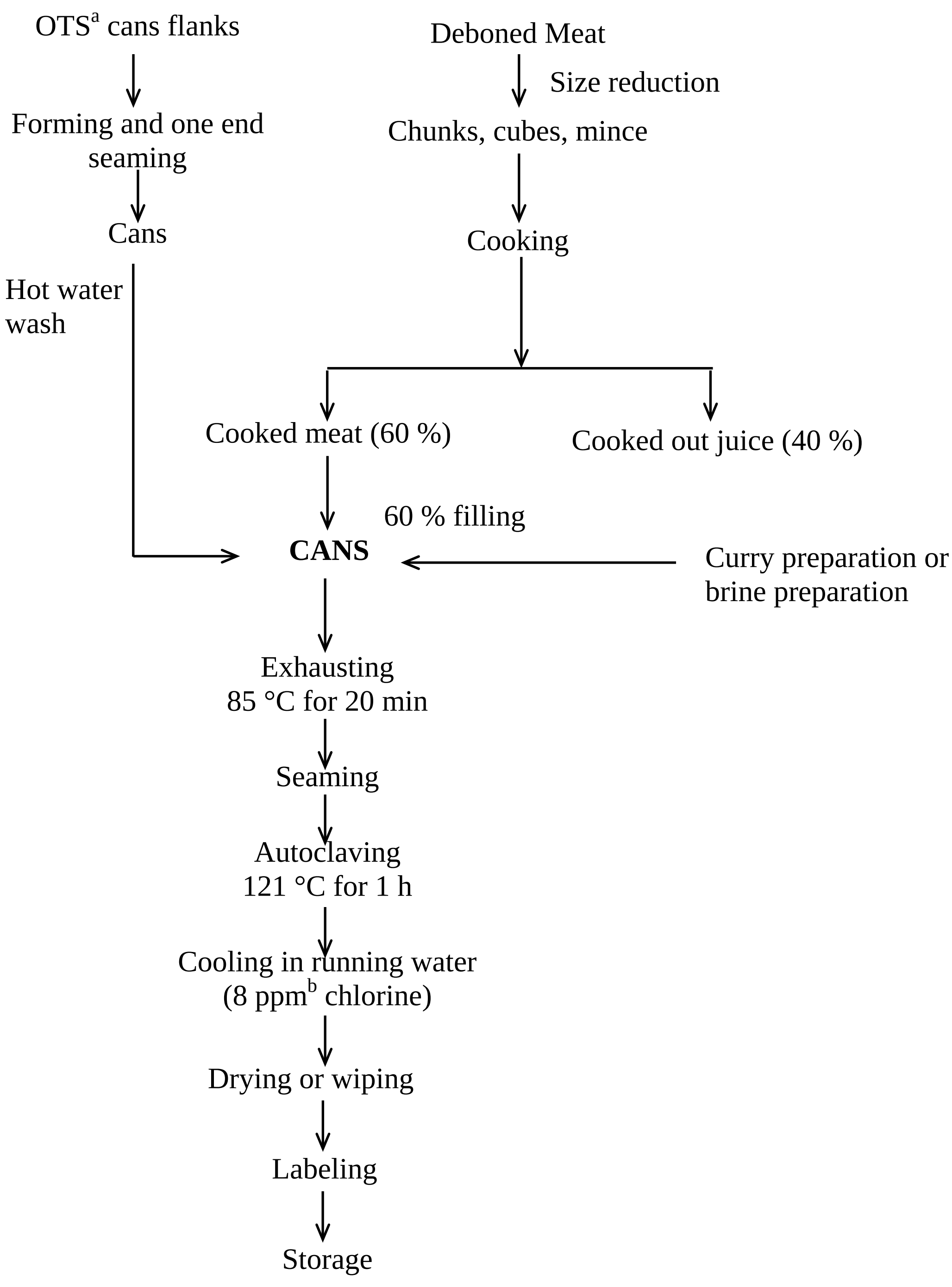

Fig. 1. Canning of meat in brine / curry

[1]Open top sanitary; [b]Parts per million.

Source: Modi 2007.

Roll stock		
Pouch forming	Pouch opening	
Product	Filling	
	Removal of air	
	Closure and sealing	
		Inspection
	Retort loading	
	Retort processing	
	Retort unloading	
		Inspection
	Drying	

Fig. 2. Processing steps for meat products in retort pouch

Source: Prabhat Kumar Mandal 2011.