International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2019): 7.583

Advances in Meat Preservation and Safety

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Abstract: ***Meat preservation is an ancient old technological development. The foremost aspects of meat preservation are mainly focused to delay of microbial spoilage and chemical reaction, and protect the meat from losing its weight and also if any change in taste and texture. Majorly, two different technological aspects are followed both thermal and non-thermal processing of meat preservation. Each technique involved is considered as a hurdle to minimise microbial proliferation and combinations of process called hurdle technology, which can be applied to achieve preservative qualities in meat preservation. The empirical observation that drying and salting, would preserve meat without refrigeration was made several thousands of years ago. This reviews deals majorly about the thermal and non-thermal technologies available to date and their advantages and disadvantages of meat preservation envisaged.***

Keywords: Meat preservation, Thermal, Nonthermal, Hurdle

1. Introduction

Meat can be stored safely for long periods by following the correct hygienic procedures. This includes that the surfaces which are exposed during meat processing should have a high degree of cleanliness. The reason for the preservation of meat is in preventing contamination and delay of spoilage by microbial enzymes and inherent enzymes of meat from damaging it. Meat preservation depends on procedures and processes to manage microbial growth and the effect of enzymes on meat [1]. To maintain the aseptic conditions, natural coverings like shell of egg, fat or skin of animals occur while the artificial covering includes maintenance of cold chain, sugar, canning, picking etc.

1.1 Precautions for food storage

The food storage area should be well lit, good air circulation and absence of drips. Floors should be well drained. Prepared food should be kept on clean racks. Raw food should not touch cooked food because there are chances of cross contamination at the floor level.

Foods like milk and meat should be stored below refrigerated temperature while frozen foods are kept at -18^{0}C. Hot foods should be stored hot while the cold foods should be kept cold. Cooked foods must be consumed after preparation otherwise should be kept at higher than 60°C. If the foods are only warmed and not heated there is a chance of multiplication of microbes [2].

1.2 Various methods of food preservation

There are some other methods of food preservation that are used in the food industry and require special equipment, for example, irradiation and vacuum packing. Irradiation is the process of exposing food to ionising radiation in order to destroy microorganisms. Vacuum packing depends on the removal of oxygen from food packaging to prevent the growth of aerobic bacteria that will decompose the food.

1.3 Thermal Methods

a) Preserving by Drying (Dehydrating)

Drying has been used since time immemorial for preserving herbs, fruits, vegetables and meats. If the moisture content is 10-20% by weight, then the bacteria cannot multiply and the enzymes are inactivated [3]. One traditional form of dried food is *quanta*. *Quanta* are made from sliced meat which is hung in the air to dry. A more modern method of drying is to use an electric dehydrating machine. Modern drying techniques make use of fans and heaters in controlled environments. Drying can be done at home using your stove and oven. Cut meat into narrow strips with a cross section of 1cm x 1cm. Boil for 5 minutes to kill bacteria and bake in an oven. Meat dehydrated this way will last 1-2 months in air-tight containers without refrigeration [4].

b) Preserving by Canning

Canning is a popular way of preserving fruits, vegetables and meats. Cans, plastic container and glass jars are suitable for canning. They are lowered in a container with hot water for 10 minutes with the lids and cooled immediately to 38^{0}C [5]. Oxygen is removed during this process. Any bulged can is not good for consumption. Since some organisms can survive canning process other additives are also added. Some familiar examples of the former class of food additives are sodium benzoate and benzoic acid; calcium, sodium propionate, and propionic acid; calcium, potassium, sodium sorbate, and sorbic acid; and sodium and potassium sulphite, calcium, sodium ascorbate, and ascorbic acid (vitamin C); butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT); lecithin; and sodium and potassium sulphite and sulphur dioxide [6]. Benzoic acid, citric acid, propionic acid, sorbic acid and their salts are effective mold inhibitors. Acetic acid and lactic acid prevent the bacterial growth whereas sorbate and acetate are capable of arresting the growth of yeasts in food [7].

Hot, high-pressure steam cooks, seals and sterilizes the meat in the canning jars. Use either the hot pack or raw pack method to preserve poultry. The hot pack method is best for the cut meat. During this process the meat is processed by roasting, stewing in little fat. In raw pack method, boiling meat broth, tomato juice, or water, is added to the top of the poultry [8]

c) Preservation by smoking

Smoke is an ancient preservative technique as earlier as man had started consumption of meat. The food is exposed to smoke from burning wood or any other plant materials. This method helps to preserve the food partially by surface drying in which the moisture is removed from the surface, but this cannot be reliable one for preservation unless this can be combined with either salting or drying method. It also keeps the meat tender if the smoke is not hot enough to cook the meat [9]. Smoking causes the outer covering to dry so that the moisture level would be reduced to a stage at which bacteria cannot enter. This also can be processed in combination with salting method. Common smoking methods are hot smoking, smoke roasting and cold smoking. Smoke roasting and hot smoking both the methods cook the meat whereas the cold smoking does not cook the meat. When the meat is processed through cold smoking, it should be dried quickly to limit the bacterial growth by making it jerky or by slicing it thinly. Also should take care of the smoking by not directly smoke with wood smoke as it leads to develop food with carcinogenic polycyclic aromatic hydrocarbons [10].

d) Cold smoking

This involves saturating the meat to smoke at a optimum temperature ranges from 75°F to 120°F (23.8°C to 48.88°C) after partially or fully cured. In this process, the meat is usually be hung or placed on racks, and allowed to be smoked for days instead of hours which resulted the product either completely raw or partially cooked. This when combined with salt curing, the product will remain edible and tasty for a year or longer without the need of refrigerated condition. This technology can be utilised for all types of meat including poultry, fish and game [11].

e) Hot smoking

Hot smoking is done with temperatures ranges from 140°F to 200°F (60°C to 93.33°C). Here in this method, without curing, the meat will be hot smoked with mild addition of salting to inhibit bacterial growth during the smoking process. Then after it is hot smoked for several hours finally before consumption. In addition to flavouring and smoke based preservatives, hot smoking is used to dry the meat further with the famous double smoked red herring. These meats are completely cured before smoking.

In both processes, the meat is completely dried at the top of the surface before smoked. In few cases cold smoking is followed by a period of hot smoking. The smoking process, either one process gives best flavours to the meat, which improve the shelf life and can last for 1-2 months in a air tight container [12].

1.4 Non -Thermal Methods

a) Preservation by Freezing method

This is one of the best methods of preservation of foodstuffs including all types of meat and this method preserve as equally as to natural state by slowing down the enzymatic reactions and growth of microbes. But the organisms will be deactivated rather than killed and possibly could be activated once the frozen product is thawed. Microorganisms such as bacteria and yeast grow well at specific temperatures usually between 40-140º F (4.4°C -60°C). By lowering the temperature approximately Under freezing condition that is below below 4°C (40ºF), their multiplication will significantly be arrested without killing them instead making them slow spoilage. Critically a minimum storage temperature of no less than 10°F (-12°C) is important for longer shelf life with desired characteristics without losing flavour. But this could be possible only with the availability of a freezer and reliable power uninterrupted power supply [13].

The meat or cut portions should be wrapped with freezer paper or bags to prevent freezer burn and also to make sure for air tightness to avoid contamination. Uncooked meat such as steaks or chops could be frozen safely for 4-12 months and further uncooked ground meat also could safely be stored for 3-4 months whereas the cooked meat can be stored for 2-3 months. Hotdogs, ham and lunch meats can be frozen for 1-2 months but the poultry meat of both cooked and uncooked may be stored for 3-12 months. Also, wild game may be kept for 8-12 months in case if a freezer or cooler maintain temperature at 0° F (−18 °C) or less of it or use an electric freezer to avoid cumbersome steps to make it. Also make sure to fill the cooler with ice on the bottom and then place meat and then cover with more ice. By ensuring meat is surrounded by ice to ensure complete and uniform freezing.

All the foods including meat begins to freeze at different temperatures about –0.6°C (21.2°F) for certain kinds of fish to –7°C (19.4°F) for fewer kinds of fruits depending upon their cellular composition. The important factor is the rate at which food is being frozen is the foremost aesthetic reasons. If the food is slowly frozen, the ice crystal formed will be larger, which leads to cause the rupture of cells and the destruction of texture in meat, fish, vegetables, and fruits. To overcome this problem, the method of quick-freezing has been developed, in which a food is cooled below its freezing point as quickly as possible. The final product obtained tends to have a firm, and natural texture than the method of slow frozen technology when it is thawed. It is important to maintain at temperature at or below -12°C in case of the product needs to have good shelf life without losing its flavour. This technology may change the texture of most of the fruits and vegetables but meats and fishes are doing well for this technology [14].

Thawing of meat and meat products is very important to reduce the chance of food-borne illness and it can be done at the refrigerator. Therefore items such as turkey meats should be thawed it by submerging the meat in an air tight packaging by changing of cold water every 30 minutes until it gets thawed completely [15].

b) Chilling

Chilling can retard the multiplication and metabolic activities of pathogenic bacteria, viruses and toxins in food stuffs unlike higher temperature. Certain parasites such as *Taenia* cysts (beef) and all stages of *Trichinella spiralis*, might be completely destroyed by storing of infected food at 18ºC for periods of 20 to 30 days and it does by the rate of cold penetration. Chilling is normally being done at

temperature from 0ºC to +8ºC for preservation of a wide variety of food products including meat [16].

c) Freeze-drying

FD is a technology which is using the physical principle called as sublimation, which is a process by which a solid passes directly to the gaseous phase without melting the ice formed. It is a best way of preserving food at low temperatures from –10°C to –25°C and the in which the chemical reactions will be at very slow phase and the microorganism finds difficult for its survival. In this method of preservation, the food items will be frozen first and then sublimes to leave the final moisture content of as low as 0.5%.

d) Preserving by adding Salt i.e. curing meat

Curing of meat has been an age old technique for preservation of meat. With the advances in the modern means of preservation curing has been used as an additional step for its impact on the taste and texture of food. In poor nations curing is still a means for viability of meat and its downscale operations like production, transport and access [17]. Curing is a general term that covers salting, sugaring and smoking are all methods of curing foods used for all types of food preservation. Salting is the addition of sodium chloride to food and it preserves the meat by absorbing water and delaying the growth of microbes. In this manner, salt, in combination with other measures, acts as a preservative in many foods such as butter, cabbage, cheese, cucumber, meat and fish. It also gives a desired flavour to the food. Salting can be done by rubbing salt on meat or is soaked in brine containing atleast 18% salt. The injection of salt solutions into meat has also become popular [20]. Curing also involves preserving food items by combinations of salt, nitrates, nitrites, or sugar, by drawing moisture out of the food by the process of osmosis [18]. Concentrations of at least 65%, sugar solution is widely used as a sweetening and preserving agent. It has been found that microorganisms rarely survive in solutions above 20–25% sugar concentration. Dehydration was the earliest form of food curing. By decreasing the water potential, it becomes difficult for microbes to grow [19].

1.5 Nitrates and nitrites

Nitrates and nitrites are antimicrobial and give a pink or red color to meat. Nitrite is obtained from sodium nitrite and potassium nitrate. They in conjunction with salts aid in preventing pathogens like *Clostridium perfringens*. Meats from various resources by this treatment preserve the properties, taste, texture, color and are also safe. Nitrates application on meat is for a limited time while the formation of Nitrite from Nitrates takes a longer time which further forms nitric oxide (NO) [21]. No binds with the iron atom in the myoglobin region which gives a reddish color when raw and the ham pink color when cooked. The color in the meat is due to the formation of nitrosomyoglobin and later due to nitrosohemochrome. Maximum allowed nitrite concentration in meat products is 200 ppm. The effect is seen for red or processed meat, but not for white meat or fish [22].

1.6 Fermentation and pickling

Fermentation is a controlled microbial reaction. It results in the production of acid and alcohol by the anaerobic or partially anaerobic oxidation of carbohydrates. High concentration of salt in pickling also acts as barrier for pathogens and undesirable bacteria. The food material results in the formation of an edible product. The concentrations of the pickling agents and the time needed for pickling are determined by the type of food [23, 24].

1.7 Irradiation

Irradiation is also known as “cold sterilization”. The radiations affect the microbes by DNA damage and ionization of water. Gamma radiations produce desired effect only during food exposure and popularly used for increasing the shelf life. UV radiations are mostly bactericidal in nature and used for surface sterilization of meat [7].

1.8 Hydrostatic pressure processing

High pressure directly affects cellular physiology of the microorganisms and used as an additional final step during processing without disturbing its native sensory attributes.. High pressure of a few hundred MPa reduces the survival of bacterial cells, while a pressure of a few tens MPa can affect its growth rate [7].

1.9 Hydrodynamic pressure processing

The concept of tenderizing meat using shock waves from underwater detonation of explosives is called hydrodynamic pressure processing. The shock wave creates pressure on vacuum-packaged meat in the range of 70 MPa to 100 MPa and reduces the microbes which may be present. The HDP-The treated meat in this method shows no outward signs of change, but on cooking, it was found to be significantly tender than the control [7] [25].

2. Conclusion

Several advanced thermal and non-thermal methods like super-chilling, ultra rapid freezing, immersion vacuum cooling, hydro fluidization freezing, impingement freezing, electrostatic-assisted freezing, pressure-shift freezing, acidic electrolyzed water coupled with high hydrostatic pressure, and non-thermal plasma technique are utilized for preserving meat quality and prolongation of shelf stability. Several of these techniques are yet to be developed on an industrial scale. Singly or in combination these techniques create a hurdle for spoilage microorganisms and at the same time increase the shelf life of meat.

Acknowledgement: The author would like to thank Dr. Anil Dutt Semwal, Director, Defence Food Research Laboratory for giving the necessary support.

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