Modern Technologies in Food Preservation (Part 2)

1. Introduction

Many of the technologies that can work at home and cottage technology cannot be used at large scale operations. Hence, technologies which can be used as a continuous process were developed. The major technologies that are employed to preserve the quality and microbiological safety of foods at industrial scales can be broadly classified into 3 categories.

(i) Methods to preserve the access of microorganisms to foods
(ii) Methods to inactivate the microbes if they have gained access;
(iii) Methods to prevent or slow down the growth of spoilage organisms growth if, they are present in food and not been inactivated.

Currently used traditional preservation procedures as dealt in control of microorganisms in Foods part 1 are also part of these three categories. However, industries are looking for better and cost efficient method of food preservation. Most of these modern methods may be the modification of the existing methods. These modifications has improved the quality of food products, without the use of extreme or single technique.

Many food microbiologists have realised that improved hygiene and the application of Hazard Analysis and Critical Control Point (HACCP) techniques help to improve food quality. A major reduction in contaminating organisms will only be achieved if new techniques which can effectively control the food borne organisms are employed. It is archived by not allowing the organisms of concern to enter the food industry or the catering establishment. Such a method would take care of some momentary lapses of hygiene that could occur. However, any major method to slow down or prevent the growth of microorganisms in foods, have to be achieved, new methods needs to be designed. These methods can thus be a part of the use of 'combination preservation 'techniques. These technologies are discussed under following titles:

- ✓ Hurdle technology
- ✓ Irradiation,
- ✓ Microwave processing
- ✓ Non Thermal methods of food preservation.

2. Hurdle technology

The hurdle effect is in controlling of microbes for the preservation of foods.These methods in a stable product controls microbial spoilage, food-poisoning. They can also help in accelerating/limiting the desired fermentation process. The microorganisms present('at the start') in a food product should not be able to overcome ('jumpover') the hurdles present, otherwise the food may spoil or even cause food-poisoning .

When multiple methods are introduced in smaller doses so as to preserve the sensory and nutritional quality of food, the microorganisms present cannot overcome these hurdles, and thus the food becomes microbiologically stable and safe.

Fermentedfoods

In fermented foods a sequence of hurdles leads to a stable and safe product. Fermented food like sausages, hams, ripened cheese and Indian foods like dosa, dokla, etc. such technologies are naturally adopted .The desired competitive flora like lactic acid bacteria (LAB) are naturally adopted and over take the food-poisoning and the spoilage organisms. Hurdles in the beginning of the fermentation of salami and sausages are nitrite and salt, which inhibit many of the bacteria. However, LAB which naturally are resistant to these hurdles are able to grow and multiply, utilize the oxygen and thus cause a reduction in redox potential of the product. This in turn enhances the *Eh* hurdle, which inhibits aerobic organisms. The LAB in turn grows by metabolizing the sugars present in the food. LAB during its growth produces organic acids like lactic and acetic acid. Further the acids produced decreases the pH of the product. The acidic pH of the product is thus the next hurdle created for the spoilage organism. Hence, it would be difficult to cross such multiple hurdles by the spoilage organisms.

Shelf stable products (SSP)

Products which are heated to a certain temperatures with high moisture on the principals of hurdle technology and stored without refrigeration are called shelf stable products (SSP). These products offer advantages like, mild heat treatment (70-110°C), no requirement of costly refrigeration distribution systems, which in turn saves energy during storage. Due to medium temperature of heating it improves the sensory and nutritional properties of the food. SSP’s are heated in sealed containers (casings, pouches or cans), which avoid recontamination. However, because of the mild heat treatment these foods still contain viable spores of bacilli and clostridia, which are inhibited by an adjustment of *aw*, pH, *Eh* and low quantities of preservatives, which cause sub lethal injury to the spores.

Intermediate moisture foods (IMF)

Intermediate moisture foods (IMF) are in the water activity (aw) range of 0.90-0.60. Such foods are stabilized by the introduction of additional hurdles, like heating, preservatives, pH and *Eh.* These foods are easy to prepare and are stored without refrigeration. Transportation and marketing of such foods are cost and energy efficient. Traditional IMF based on meat, fish, fruits and vegetables are common and much liked indifferent parts of the world. This is mainly because they are tasty, nutritious, and safe. Due to the requirement of high temperature cooking IMF have its own disadvantages like poor palatability and the need to introduce often high amounts of antimicrobial additives.

Multi-target preservation of foods

A synergistic effect is something that every food technologies would dream could become true. Can we introduce multiple hurdles at the same time during the processing of food. Different targets like cell membrane, DNA, enzyme systems of the spoilage organism, along with disturbance of pH, *aw* , *Eh* within the microbial cell, disturb the homeostasis of the microorganisms. In practical terms, this could mean that it is more effective to use different preservatives in small amounts in a food than only one preservative in larger amounts. Such treatments might hit different targets within the bacterial cell and act synergistically. Appropriate water activities management by the addition of salt and fat, could become the promising area of research in future.

3. Food Irradiation:

After more than five decades of research and development to prove the safety and wholesomeness of the food, irradiation was accepted. This method of food preservation had the largest political debates and public scrutiny. Food irradiation today is established as a safe and effective method of food processing and preservation. Similar to other food preservation methods, food irradiation offers advantages and disadvantages relative to the types of food to be treated. Its role as a method to ensure hygienic quality of the more solid foods, e.g. meat, poultry and seafood, has increased its use in many countries. The Joint committee of Expert from FAO and WHO along with international agency for atomic energy, worked on the Wholesomeness of Irradiated Food (JECFI). The committee has been working from 1960 and is convened from time to time to study the safety of food subjected to ionizing radiation treatment under properly controlled conditions. The Codex Standard and its associated Code of Practice provide important principles for proper irradiation of food (up to an overall average dose of 10 kGy) and essential control procedures. The Codex Standard was recommended by the CAC to all its member countries for acceptance in 1984. A few countries are yet to accept the same. This is mainly due to the lack of facilities for large scale food irradiation and further testing of those irradiated products.

Advantages of food irradiation

Irradiation is proposed as an alternative to fumigation of food. Fumigation of food and food ingredients is commonly practiced. Fumigants like ethylene dibromide (EDB), methyl bromide (MB), ethylene oxide (ETO), has been either prohibited or is being increasingly restricted in most advanced countries. Their residues are considered deleterious to health, environmental or as occupational safety concerns. Irradiation has been demonstrated as an effective alternative to the fumigants mentioned above. Low-dose of irradiation between 0.2 and0.7 kGy can control insect infestation of grain and other stored products. Unlike fumigation, irradiation does not leave any residues in the products. Low-dose irradiation is effective in inactivating non-spore forming pathogenic bacteria and food-borne parasites. Irradiation can be used as an economical treatment for commodities such as cocoa beans, potatoes, onions, yams, and garlic, to control sprouting. Mushrooms and asparagus are irradiated to control rapid physiological changes leading to spoilage.

Limitations of food irradiation

Irradiation can neither replace good manufacturing practices nor is it applicable to all food. For example, dairy products such as milk and butter can develop an off-odour when treated by irradiation. Microbial toxins such as *Staphylococcus enterotoxin* and *aflatoxin* produced by *Aspergillus*, cannot be easily inactivated by irradiation. Virus also cannot be easily destroyed by low-dose irradiation. As this technology can handle large quantities of products a factory using irradiation must be located at a central point. Sufficient amounts of food are to be produced and transported to the plant for treatment and storage before sending it to the market.

Irradiation has a low operating cost, especially with regard to energy requirements. However, irradiation has high capital costs and requires a critical minimum capacity and product volume(s) for economic operation. As food irradiation is perceived to be associated with nuclear technology, irradiated food can be erroneously connected with radioactive materials. Thus, the introduction of food irradiation on a commercial scale requires an education campaign.

The number of countries which use irradiation for processing food for commercial purposes has increased steadily. Spices and vegetable seasonings are the most common products which have been irradiated, in about 20 countries (Table. 3). Since 1990 when the European Union proposed a ban on the use of ethylene oxidefor fumigating food and food ingredients, the use of irradiation to ensure hygienic quality of spices and vegetable seasoning has increased significantly.

4. Microwave processing

In the wider field of preservation microwaves have been used in drying, blanching and vacuum drying. Microwaves in combination with hot air have been shown to be a positive route to drying of foodstuffs. The principle behind this potential of microwaves to enhance heating rates is simple. Microwaves cover the broad range of radio frequencies from 300 MHz(million cycles per second) to 300 GHz (billion cycles per second). This corresponds to wavelengths between 1 metre and 1 millimetre, according to the equation:

$$\text{Wave length (cm)} = \frac{\text{Speed of light (cm/s)}}{\text{Frequency (Hz)}}$$

Microwaves are reflected by metals, transmitted by electrically neutral materials such as glass, most plastics, ceramics and paper, and absorbed by electrically charged materials. Microwaves penetrate deeply into food materials and as they penetrate, the energy they carry is converted to heat, actually by the food material itself, mainly by the mechanisms of polar and ionic orientation.

The aim of using microwave processing in preservation is to deliver a more homogeneous heat treatment at a faster rate than conventional heating. In general and pasteurisation or sterilisation in particular such fast flow of heat is an added advantage as the time for heating can be brought down.

The major benefits of microwave processing is it can replace the need for water or steam as a heating source. Therefore, it is possible to manufacture continuously rather than batch-wise. As this form of heating occurs *within* the material, the limitations of surface heating are reduced and the process can be greatly accelerated. This is particularly true for materials with a low thermal conductivity and for drying processes where the high dielectric loss properties of water result in selective heating of moist areas and rapid diffusion of water vapour to the surface. Energy is not used in heating the walls of the apparatus or the environment. Heat is developed where it is needed – in the material being processed. In drying processes, microwave energy is applied as the conventional drying process at a cheaper cost. Heating adjustments can be made on line with precise control.

Non thermal processing

Hydrostatic pressure technology is a non-thermal food processing technology, whereby foods are subjected to high hydrostatic pressure (100-600 MPa) at normal ambient temperature. Since HHP denatures proteins and polysaccharides, the technology also presents interesting applications in the area of food texturisation. However, this may also change the taste and texture of food. This sometimes may not be acceptable to the consumers. At present no commercial HHP processed foods are produced.

Modified-Atmospheric packaging (MAP):
The replacement of air in a packed food by a different mixture of gases is known as MAP. The proportion of each gas is fixed when the mixture is introduced during food packing, The ability of modified-atmosphere packaging (MAP) to extend the shelf life of foods has been recognised for many years. There are several techniques by which the atmosphere surrounding a product can be modified.

• *Controlled- Atmospheric packaging (CAP):*
CAP is a condition in which the composition of gases in the pack is continuously controlled throughout storage. This technique is used primarily for the bulk storage of products and requires constant monitoring and control of the gas composition.
•*Equilibrium-modified atmosphere (EMA):*
The pack is flushed with the required gas mixture or the product is sealed with modification to the atmosphere. The respiration of the product and the gas permeability of thepackaging material allows an EMA to be reached. It is used mainly for fruit and vegetables
• *Vacuum packing (VP):*
*T*he air is evacuated and the package sealed. During storage from metabolism of the product or microorganisms . The gas produced changes and therefore the atmosphere becomes modified indirectly.
The advantages and disadvantages of MAP is listed in table 2

Aseptic processing

Aseptic transfer of sterilised materials into sterile containers is a common method of pure culture management. Food which is sterile Eg Coconut water (tender coconut) is subjected to filling into a decontaminated container within an aseptic filling zone. However all food contact surfaces should be sterilised before production starts and have to be maintained in the same condition. The major limitations of this technology is that only those foods which are in sterile condition in nature can be packed using this technology.

5. Microbial decontamination by organic acids

A number of products are traditionally preserved using organic acids. Eg. Fish Preserved using Garcinia extracts. The antimicrobial effects of organic acids have been known since time immemorial. For examples, bacteria convert lactose into lactic acid, and lactic acid has been used from a long time to change flavours, composition and consistency. This was used in softening of meat and its texture improvement. Now these acids are synthetically produced and are used in food preservation. Both acetic and lactic acid used individually or in combinations enhanced the antimicrobial effects. A large number of foods are pickled using these acids. Eg. Gerkins, vegetable pickles etc. organic acids behave as preservatives changing the micro environment into an acidic environment and also by acting on the cell membranes of the spoilage organisms.

Conclusions

Food irradiation is becoming a major technology in feeding the world's increasing population. This method is used to maintain the food of animal origin, spices, grain and other stored products from insect infestation and microbial spoilage. It is an energy saving method to maintain food quality. Microwave processing in the preservation area is fast being accepted. Further advances needs to be brought in before this method is widely accepted.

The use of organic acids as decontaminating agents is not ideally used for all foods.

Product packaged in MAP is now a common packing in the market. This is mainly due to the development of intelligent packaging, and materials available today. A combination of these techniques through the method of hurdle technology is the most practiced method of food preservation today.