PRINCIPLES OF FOOD PRESERVATION

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Summary

Food preservation involves the action taken to maintain foods with the desired properties or nature for as long as possible. The process is now moving from an art to a highly interdisciplinary science. This chapter provides an overview of food preservation methods with emphasis of inactivation, inhibition and methods of avoiding recontamination. The final section is a discussion of the factors that need to be considered in order to satisfy present and future demands of the consumers and law enforcing authorities.

1. Introduction

Throughout most of the world, innovation, sustainability, and safety have become the main foci of modern industry and economy. The United Nations World Commission on Environment and Development defined sustainable development as “meeting the needs of the present generation without compromising the ability of future generations to meet their own needs". Innovation is vital to maintain progress in technology. Food safety is now the first priority of the food production and preservation industry, incorporating innovation and sustainability. The industry can compromise with quality to some extent but not with safety.

The preservation and processing of food is not as simple or straightforward as it was in the past. It is now moving from an art to a highly interdisciplinary science. A number of new preservation techniques are being developed to satisfy current demands of economic preservation and consumer satisfaction in nutritional and sensory aspects, convenience, safety, absence of chemical preservatives, price, and environmental safety. Understanding the effects on food of each preservation method has therefore become critical in all aspects. This chapter provides overviews of the new technology, identifying the changing demands of food quality, convenience and safety.

2. Food Preservation

Preservation methods start with full analysis and understanding of the whole food chain, including growing, harvesting, processing, packaging, and distribution; thus an integrated approach needs to be applied. Food preservation involves action taken to maintain foods with the desired properties or nature for as long as possible. It lies at the heart of food science and technology, and it is the main purpose of food processing. First it is important to identify the properties or characteristics one wants to preserve. One property may be important for one product, but detrimental for others. For example, collapse and pore formation occurs during the drying of foods. This can be desirable or undesirable, depending on the desired quality of the dried product, for example, crust formation is desirable for long bowl life in the case of breakfast cereal ingredients, and quick re-hydration is necessary (i.e. no crust) for instant soup ingredients. In another instance, the consumer expects apple juice to be clear whereas orange juice can be cloudy.

Another important question is *why* to preserve a food. The main reasons for food preservations are to: overcome inappropriate planning in agriculture, to produce value added products, and to provide variation in diet. The agricultural industry produces raw food materials in different sectors. Inadequate management or improper planning in agricultural production can be overcome by avoiding inappropriate areas, times, and amounts of raw food materials as well as by increasing storage life using simple methods of preservation. Value-added food products can give better-quality foods in terms of improved nutritional, functional, convenience and sensory properties. Consumer demand for healthier and more convenient foods also affects the way that food is preserved. Eating should be pleasurable to the consumer, and not be boring. People like to eat wide varieties of foods with different tastes and flavors. Variation in the diet is important, particularly in under-developed countries in order to reduce reliance on a specific type of grain (i.e. rice or wheat).

In food preservation, the important points that need to be considered are:

- what quality level is desired?
- how long to preserve? and

- for whom to preserve?

After storage of a preserved food for a certain period, one or more of its quality attributes may reach an undesirable state. Quality is an illusive, ever-changing concept. In general it is defined as the degree of fitness for use, or the condition indicated by the satisfaction level of consumers. When food has deteriorated to such an extent that it is considered unsuitable or unsafe for consumption, it is said to have reached the end of its shelf life. In studying the shelf life of foods, it is important to measure the rate of change of a given quality attribute. In all cases, safety is the first attribute, followed by other qualities. Sell-by date is also used in determining product quality. It includes a generous safety margin before the shelf life and the food is actually still perfectly edible at the stated dated. The product quality attributes can be quite varied, such as appearance, sensory, or microbial characteristics. Loss of quality is very dependent on types of food and composition, formulation (for manufactured foods), packaging, and storage conditions. Quality loss can be minimized at any stage of food harvesting, processing, distribution and storage. When preservation fails, the consequences range broadly from the food becoming extremely hazardous to minor deterioration, such as color loss.

The required length of preservation depends on the purpose. In many cases, very prolonged storage or shelf life is not needed, which simplifies both the transport and marketing of the foodstuff. For example, prepared meals for lunch need a shelf life of only one or even half a day. In this case there is no point in ensuring preservation of the product for weeks or months. In other cases very long shelf life up to 3 to 5 years may be required, e.g. foods for space travelers, and food storage during wars.

It is important to know for whom the preserved food is being produced. Nutritional requirements and food restrictions apply to different population groups. Food poisoning can be fatal, especially in infants, pregnant women, the elderly, and those with depressed immune systems. The legal aspects of food preservation are different in case of foods produced for human or animal consumption. Thus, it is necessary to consider the group for whom the products are being manufactured.

3. Causes of Deterioration

Mechanical, physical, chemical and microbial effects are the leading causes of food deterioration and spoilage. Damage can start at the initial point by mishandling of foods during harvesting, processing, and distribution; this may lead to ultimate reduction of shelf life. Other examples of deterioration can be listed as follows: (i) bruising of fruits and vegetables during harvesting and post-harvest handing, leading to the development of rot, (ii) tuberous and leaf vegetables lose water when kept in atmospheres with low humidity and subsequently wilt, (iii) dried foods kept in high humidity may pick up moisture and become soggy. The four sources of microbial contaminants are soil, water, air and animals (insects, rodents, and humans). The major causes of quality loss are shown in Table 1. In preservation each factor needs to be controlled or maintained to a desired level.

Microbiological	Enzymatic	Chemical	Physical	Mechanical
Microorganism growth	Browning	Color loss	Collapse	Bruising due to vibration
Off-flavor	Color change	Flavor loss	Controlled release	Cracking
Toxin production	Off-flavor	Non-enzymatic browning	Crystallization	Damage due to pressure
		Nutrient loss	Flavor encapsulation	
		Oxidation-reduction	Phase changes	
		Rancidity	Re-crystallization	
			Shrinkage	
			Transport of Component	

Source: based on Gould (1989)

Table 1. Major quality loss mechanisms

4. Food Preservation Methods

Based on the mode of action, the major food preservation techniques can be categorized as: (1) slowing down or inhibiting chemical deterioration and microbial growth, (2) directly inactivating bacteria, yeasts, molds, or enzymes, and (3) avoiding recontamination before and after processing. A number of techniques or methods from the above categories are shown in Figure 1. Whilst the currently used traditional preservation procedures continue in one or more of these three ways, there have recently been great efforts to improve the quality of food products, and principally in order to meet the requirements of consumers through the avoidance of extreme use of any single technique. Preservation starts when the harvested foods are separated from the medium of immediate growth (plant, soil, or water) or meat from the animal after slaughter, or milk from normal secretion of mammalian glands. Raw foods are those in the earliest or primary state after harvesting, milking or slaughter; they have not been subjected to any treatment apart from cleaning, and size grading, etc. in the case of foods of plant origin. Post-harvest technology is concerned with handling, preservation and storage of harvested foods, and maintaining its original integrity, freshness and quality. The methods of preservation depend on the origin of foods—particularly whether they are of plant or animal origin. Post-harvest handling of foods of plant origin includes efficient control of environmental atmosphere, such as humidity, gas composition, and temperature, and implementing an adequate packing, storage, and transport system. Physical treatments usually used are curing, pre-cooling, temperature treatments, cleaning, and waxing, whereas chemical treatments are disinfection, fumigation, and dipping. Meat is the edible flesh of any of a number of species of mammal or bird, both wild and domesticated. Post-harvest quality is affected by slaughter conditions or stress before death.

In the case of foods, preservation methods include chilling, electrical stimulation (mainly for meat and fish), and decontamination methods, e.g. hot water rinsing with or without chlorination, decontamination with phosphate, hydrogen peroxide, chlorine,

chlorine dioxide and ozone, and surface treatment by organic acids. Pretreatments, such as blanching, sulfiting, and other physical and chemical pre-treatments are used before applying major preservations methods. The main purpose of pretreatment is to improve product quality and process efficiency. In recent years altering processing strategy and/or pretreatment has gained much attention in the food industry.

The steps of cleaning and sanitization are important in food preservation. Chemical disinfectants vary in their ability to kill microorganisms. Effectiveness depends on the types of microorganisms, their attachment mechanisms, and physical characteristics of the produce. Some disinfectants are appropriate for use in direct contact washes, others only for process water, processing equipment or containers, and facilities. It is important to know disinfectants' mechanisms of action effectiveness, as well as the relevant microbial biochemistry. Several chemicals are utilized, such as chlorine, chlorine dioxide, hydrogen peroxide, ozone, peroxyacetic acid, bromine, iodine, trisodium phosphate, and quaternary ammonium compounds. Although fumigants not strictly preservatives, they are used for insect control. Methyl bromide is one of the fumigants used, but it has potential to damage atmospheric ozone and is being phased out. There is a need for development of new environmentally safe methods of fumigation.

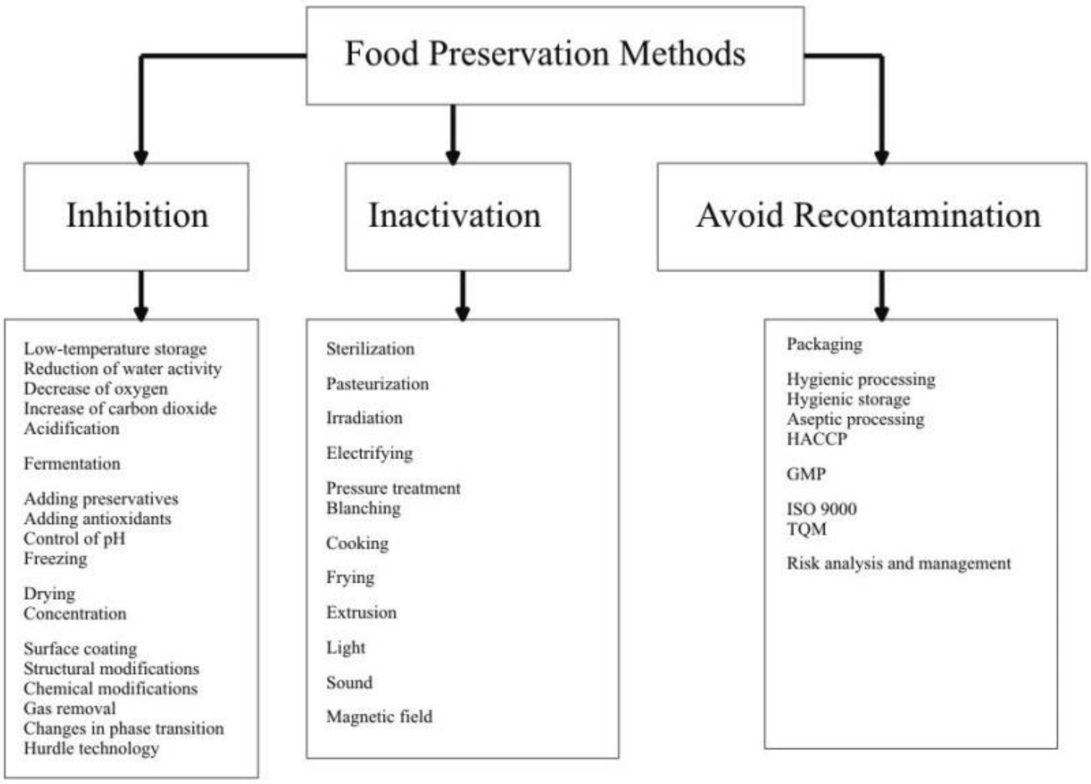

Figure 1. Major food preservation techniques (Gould, 1989; Gould, 1995).

4.1. Inhibition

The methods based on inhibition include those that rely on control of the environment (e.g. temperature control), those that result from particular methods of processing (e.g. micro-structural control), and those that depend on the intrinsic properties built in to particular foods (e.g. control by the adjustment of water activity or pH value. The danger zone for microbial growth is considered to be between 5 and 60 ^{o}C; thus food products chilled and stored at a temperature below 5 ^{o}C is one of the most popular methods of food preservation.

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Biographical Sketch

Mohammad Shafiur Rahman is an Associate Professor at the Sultan Qaboos University, Sultanate of Oman. He is the author or co-author of over 150 technical articles including 54 refereed journal papers, 49 conference papers, 30 reports, 5 popular articles and 2 books. He is the author of the internationally acclaimed and award winning Food Properties Handbook published by CRC Press, Boca Raton, Florida, which received one of the bestseller awards from CRC press in 2002. He is Editor of the Handbook of Food Preservation published by Marcel Dekker, New York, which also secured a bestseller award from publisher and was translated into Spanish by Acribia, Spain, in 2003. Both of the above books are in the process of preparation of a second edition. He was invited to serve as one of the Associate Editors for the Handbook of Food Science, and one of the Editors for the Handbook of Food and Bioprocess Modeling Techniques, which will be published by Marcel Dekker, New York. His book Food Properties: Users' Handbook is going to be released soon.

Dr. Rahman initiated the International Journal of Food Properties (Marcel Dekker, Inc.) and served as the founding Editor for more than six years. He has served as a member in the Food Engineering Series Editorial Board of Aspen Publishers, Maryland (1999-2003). In 2003 he was invited to serve as a member of the Food Engineering Series Board, Kluwer Academic/Plenum Publishers, New York. He has also been invited to serve as a Section Editor for the Sultan Qaboos University journal Agricultural Sciences (1999). In 1998 he was invited to serve as a Food Science Adviser for the International Foundation for Science (IFS) in Sweden. Dr. Rahman is a professional member of the New Zealand Institute of Food Science and Technology and the Institute of Food Technologists, and a member of the American Society of Agricultural Engineers and the American Institute of Chemical Engineers. He received B.Sc. Eng. (Chemical) (1983) and M.Sc. Eng. (Chemical) (1984) degrees from Bangladesh University of Engineering and Technology, Dhaka, an M.Sc. degree (1985) in food engineering from Leeds University, England, and a Ph.D. degree (1992) in food engineering from the University of New South Wales, Sydney, Australia. Dr. Rahman has received numerous awards and fellowships in recognition of his research and teaching achievements, including the HortResearch Chairman's Award, the Bilateral Research Activities Program (BRAP) Award, CAMS Outstanding Researcher Award 2003, and the British Council Fellowship.