CONVENTIONAL THERMAL PROCESSING (CANNING)

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Summary

This article provides the reader with an overview of conventional thermal processing operations in the food and pharmaceutical industries, and describes the state of the art in food canning technology today. Discussion begins with an introduction to sterilization and pasteurization of foods by use of heat, and the important distinction between both methods of food preservation with respect to microbiological considerations and conditions of heat treatment. The difference between thermal processing (in-container sterilization) and aseptic processing (out-of-container sterilization) is briefly explained, while the focus remains primarily on thermal processing. A brief history covering the early discovery and gradual evolution of food canning technology leading up to the current state of the art is also given.

Equipment systems currently used by the food and pharmaceutical industries are described in detail with photographs and schematic diagrams explaining the principles of operation. These include batch retorts (autoclaves) and continuous rotary, hydrostatic, and crateless systems. The scientific principles needed to specify processing conditions are fully explained. These include microbiological considerations and knowledge of thermal inactivation kinetics of bacterial spores, as well as engineering

principles of heat transfer and mathematics. Methods are described for calculating the process times needed at specified retort temperatures in order to achieve a given level of bacterial lethality, and the concept of lethality is defined.

The article concludes with a discussion of future trends and perspectives. These include the recent and continuing development of new and novel packaging systems for shelf stable foods in military, institutional, and consumer markets, as well as recent advances in process technology. Specifically, mathematical models for computer simulation of thermal processes are described, and their application to intelligent on-line computer-controlled food canning operations to ensure food safety at maximum quality and minimum cost.

1. Introduction

Canning is a method of sterilizing food by heat in hermetically sealed (airtight) containers, which allows ready-to-eat foods that are neither frozen nor dehydrated to remain safe and wholesome during months or even years of storage at room temperature without the use of additives or preservatives. In addition to playing an important role in the feeding of humankind throughout the world, this technology is used to produce a wide variety of sterile hospital solutions and pharmaceuticals for the health care industry. Within the food industry and food science community, this technology is referred to as thermal processing.

Both sterilization and pasteurization are thermal processes that make use of heat treatments for the purpose of inactivating microorganisms in foods. However, they differ widely with respect to the classification or type of microorganisms targeted, and thus the range of temperatures needed, and the type of equipment systems capable of achieving such temperatures. Pasteurization is used to inactivate food-borne pathogens, which are vegetative bacterial cells with relatively low heat resistance. These organisms can be effectively inactivated when exposed to temperatures of 75 to 95^{o}C, which is below the boiling point of water under standard conditions. These are also the organisms of concern when attempting to prolong the safety and wholesomeness of fresh foods intended for limited periods of refrigerated storage. The more highly heat-resistant bacterial spores remain unaffected by pasteurization and will eventually spoil the food. Thus, pasteurization is a relatively mild heat treatment used in conjunction with refrigerated storage.

In order to achieve long-term microbial stability in foods, it is necessary to inactivate the more highly heat-resistant bacterial spores that require temperatures in the range from 110 to 150^{o}C. These temperatures are well above the boiling point of water under standard conditions, and can only be achieved by using water (or steam) under pressure in specialized equipment.

Because of the severity of these treatments, they also accomplish the objectives of pasteurization, and are capable of rendering the food commercially sterile. Thus, this particular heat treatment is known as sterilization, and is the type used in canning. Because of its greater complexity and importance in the marketing of shelf-stable foods, much of the following discussion will address thermal processing as applied to the

sterilization of canned foods (canning).

2. Historical Perspective

The practice of canning as a method of food preservation originated in the early 1800s in France, when Emperor Napoleon Bonaparte offered a prize of 12 000 francs to anyone developing better, more diversified foods for the feeding of troops during military campaigns. A man named Nicholas Appert won the prize for successfully preserving, for the first time, a variety of perishable food products by heat-processing foods in glass jars and bottles. At the time of Appert's discovery, the reasons for food spoilage were not known. Louis Pasteur discovered the existence of microscopic organisms and the use of heat in their destruction many years later. This work was a major contribution to the beginning of the canning industry.

From Appert's work, and the invention of the metal container and pressure cooker or retort, evolved the present-day technology of thermal processing. The development of metal and glass containers capable of withstanding added internal pressure was a major breakthrough. This made possible a concurrent development of devices that permitted the exposure of the filled/sealed containers to steam pressures above atmospheric pressure and processing temperatures of 120ºC, instead of only 100ºC, the temperature of boiling water. Since the thermal inactivation of food spoilage organisms is a function of both time and temperature, the higher temperature under pressure allowed a considerable reduction in the time needed to ensure product sterility. Equally important, however, was the marked improvement in canned food quality.

3. Current Technology

There are two fundamentally different methods used for the canning process in the food industry. These methods are retort processing and aseptic processing. In retort processing, cans, jars, or other retort containers are filled with foods and sealed, then heated using saturated steam under pressure until heat penetrates the product from the can wall inward and both product and can wall become sterilized together. In aseptic processing, a liquid food is first sterilized outside the container by pumping it through heat exchangers that deliver very rapid heating and cooling rates. The cooled sterile product is then filled and sealed in a separately sterilized package under a sterile environment at room temperature. Thus, retort processing can be thought of as "in-container" sterilization, which can be applied to all types of foods. Aseptic processing can be thought of as "out-of-container" sterilization, but is limited to liquid foods.

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Biographical Sketch

Arthur A. Teixeira is a Professor of Agricultural and Biological Engineering and an affiliate Professor of Food Science and Human Nutrition at the University of Florida, where he teaches courses in food properties and food engineering unit operations. His research interests include engineering design of food preservation and sterilization processing systems; and mathematical modeling for computer simulation, optimization, and control of food process operations. He was a Fulbright lecturer and researcher in Portugal and Peru, as well as a visiting scientist and professor in Sao Paulo, Brazil. His previous industrial experience includes positions as senior consultant in food and agribusiness at Arthur D. Little, Inc.; and research engineer and group leader at Ross (Abbott) Laboratories. He earned his B.S in Mechanical Engineering, M.S. in Mechanical and Aerospace Engineering, and Ph.D. in Food and Agricultural Engineering, all from the University of Massachusetts. He is a registered professional engineer in Florida and Massachusetts, Fellow of the ASAE, and recipient of the 2001 IAFIS/FPEI Distinguished Food Engineering Award.