FOOD PROCESS ENGINEERING

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Summary

Food process engineering involves a variety of operations utilized in transforming raw agricultural commodities into shelf-stable, easy-to-use, nutritious, and safe foods. This field of study is based on an understanding of the physics and biology of food preservation processes, evolving into a widely sought specialty of engineering. The history of the field of food engineering is a story of engineers, typically untrained in the biological sciences; they developed an understanding of and quantified the chemical and biological changes associated with food spoilage, resulting in the development of processes to control them. To preserve and transform raw materials successfully into safe, nutritious, and convenient foods, economically and consistently, engineers utilize a variety of processes involving heat, cold, and automated mechanical devices.

A typical process consists of a series of unit operations, each of which must be made to match the other unit operations in the series. The process of preserving high-moisture

foods to render them shelf-stable may involve a mechanical pretreatment to clean the raw material and separate the non-edible parts, a packaging step, and a thermal processing step to inactivate food poisoning and spoilage microorganisms. Frozen and dried foods require a blanching step prior to freezing or dehydration. Quality considerations differ when selecting optimum processing parameters in different modes of food preservation. The processes of dehydration, canning, and freezing are the most important processing treatments for foods. However, when processed products with fresh-like qualities are desired, the severity of the heat or cold treatments must be minimized and new methods used to inactivate or retard the growth of spoilage microorganisms. Thus, non-thermal methods for food preservation have emerged. Separation techniques for different compounds found in naturally occurring raw food materials have evolved to isolate a very valuable component from the mixture, or to remove undesirable components. Thus, a raw material may be separated into several fractions, each fraction having optimal functional properties when used in a suitable food system. Separation techniques may also be used to recover waste substances and to convert them into high-value food ingredients. This overview discusses briefly how food engineers are involved in the development and manufacturing of modern convenient food products.

1. Food Process Engineering Overview

Food preservation has been practiced since ancient times. One reason for the success of cereal grain as a food resource is that it is shelf-stable after harvest, as long as it is kept dry. For other agricultural products, a limited storage life requires that products be treated following harvest for conversion into more shelf-stable forms. This practice of preserving perishable foods in times of bountiful harvest for use later, before the next harvest, is the foundation of the food preservation industry. The process of dehydrating, salting, curing, pickling, and heating in syrup has commonly been used to preserve meats, fruits, and vegetables in farm households. Origins of the modern food processing industry can be traced back to the urbanization of society when crops and livestock began to be raised on farms far from population centers. The large demand in urban areas for traditional farm produced food products (for example, fresh and cured meats, dairy products, fruit preserves and confections, pickled vegetables, and canned foods) necessitated a shift in production from household kitchens to industrial food facilities. Today, the food industry is one of the largest and most diverse manufacturing sectors in the industrialized world. The industry extends from agroproduct or marine product processing to consumer food product manufacturing and food distribution.

2. Scope of Food Process Engineering

Food process engineering is a rapidly evolving field that deals primarily with manufacturing processes involved in the transformation of raw materials of biological origin into more convenient forms. End products in a food processing plant include ready-to eat food entrees that require short preparation time prior to serving, ready-to-cook food ingredients that allow consumers to prepare a meal rapidly using their own menu and recipes, and industrial ingredients utilized by other food processing plants to produce consumer food products. Food comprises the largest share of a family's expense budget, so affordability, quality, and convenience play major roles in food buying decisions. In addition, the safety of commercially processed food from the hazards of food-borne pathogens is an uncompromising criterion set by regulatory agencies and consumers in a litigious society. Chemical hazards resulting from chance contamination in a processing plant or during storage and distribution, and physical hazards brought about by contamination of the product with non-edible or foreign material, could harm consumers and exact an economic toll on the company producing the product. In addition to being fully functional, food-processing equipment must be designed for ease of cleaning and sanitation. Food processing plants also must be properly designed and laid out to prevent product contamination by extraneous material, pathogenic microorganisms, or spoilage microorganisms. These demands on food manufacturers have transformed an industry that once depended primarily on manual labor and batch-wise processing into one that uses continuous processing systems and the latest in automation, using sophisticated sensors for process control.

Food manufacturing processes are best understood if broken down into processing subsets called *unit operations*. Transformation of a raw material into a consumer product will involve either one or a series of unit operations to impart the desired characteristics to the finished product.

3. Raw Material Preparation

Fruits, vegetables, and animal products, including fish, shellfish and marine plants, are typical raw materials in a food processing operation. These raw materials are high in moisture, contain inedible portions, and are perishable. The object of food processing is to separate the edible from the inedible portions, transform the edible constituents into traditional forms for consumption, stabilize the product against spoilage for prolonged storage, eliminate pathogenic microorganisms, and provide convenience by conversion into a form that requires short preparation time prior to serving. In the case of dry raw materials, such as cereal grains and oilseeds, processing involves size reduction and separation of inedible from edible constituents, and conversion of the edible fraction into one or more functional forms. A dry separation process may be used, as in the milling of wheat into flour, or a liquid medium may be used to facilitate component separation, as in wet milling of corn to produce starch. The addition of solvents to extract oil from soybeans is another example of a solid–liquid separation process. All processing operations produce a primary product and by-products. Today's restriction on solid waste disposal in many localities requires that the latter be recovered, and the edible components separated and converted into forms suitable for use as ingredients in other food products. Inedible by-products may be stabilized by drying or composting, or transformed into forms suitable for recycling into the agricultural production environment.

4. Prevention of Food Spoilage

Food preservation is the major objective of food processing operations. The science of food preservation had its beginnings with Louis Pasteur's discovery in the 1880s that microorganisms are the cause of spoilage in foods. Thus, food can be preserved once the microorganisms capable of growing in the product are inactivated. Food can also be preserved if the microorganisms are prevented from growing, by removing water, or by adding microbial growth inhibitors (also known as preservatives) or both. When a food is preserved through inactivation of the microorganisms within, recontamination of the processed food with viable organisms must be prevented; otherwise, the heat inactivation treatment will be for naught. Thus, containers are filled with food and hermetically sealed, then heated to inactivate the microorganisms within. A hermetic seal is employed to prevent entry of air and microbial contaminants after processing. In the canning industry, the containers are usually sealed using a double seam to produce a secure closure. In-container heating of foods is also referred to as *terminal sterilization*. The success of canning depends on the successful terminal sterilization of hermetically packaged foods. Since not all canned foods are sterile, the term *commercial sterility* is used to describe a successfully canned product. Commercial sterility is a condition whereby all microorganisms capable of growing in the food during normal conditions of storage and distribution are destroyed. Major advantages of canned food are that it is ready to eat from the can and has a flavor and texture similar to food prepared in a home kitchen. These characteristics contrast with foods produced using other food preservation methods.

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Biographical Sketch

Romeo T. Toledo, Ph.D., is Professor of Food Process Engineering at the University of Georgia. His book *Fundamentals of Food Process Engineering* (Aspen Publishing) is the most widely used text and reference book in the field worldwide. He has published extensively in the areas of thermally induced changes in muscle food systems affecting texture, water binding, and preservation; accelerated infusion of solutes into foods and fluidized bed dehydration; and water relations in foods needed to produce minimally processed preserved foods. His research has demonstrated that water activity in muscle foods can be reduced to levels adequate to prevent outgrowth of Clostridium spores by use of water binding agents rather than salt, sugars or polyols thus producing shelf stable products that are not too salty or sweet. His research on continuous flow high pressure processing has demonstrated that microbial vegetative cells are inactivated by sudden decompression and shear at temperatures below that used in conventional pasteurization and at pressures about half that required in high hydrostatic pressure processing. Dr. Toledo holds two US patents, has published 136 scientific journal articles and book chapters, and has authored two books on food process engineering.