Chapter 14
Guiding Principles for Hygienic Design of Evaporators to Mitigate Contamination–Related Risks in Air Blast Freezing Systems

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ABSTRACT
Evaporator coils, fins and drain pans in blast freezers may act as a source of microbial, physical and chemical contamination (representing Critical Control Points within a HACCP study). For instance, the evaporator might contaminate unpacked food products passing through the freezer with undesirable ingredients remaining from a previous product being frozen. Drain pans below the refrigerating coils and fans also require paramount attention, due diligence and professional care to ensure that both frozen foods and freezer interior are kept at the highest possible hygienic level. This book chapter is, therefore, focussing on knowledge-based hygienic design of evaporators in air blast freezing systems (e.g., proper production and mounting of refrigerating coils, drain pans and fans, along with suitable materials of construction to reduce frosting, microbial fouling and corrosion) with the ultimate aim of acquiring a safe environment and extended shelf life of unwrapped products. An overview of the existing types of air blast freezers is presented for that purpose. Furthermore, the today’s state of the art is introduced to food chain operators who are not enough familiar with hygienic design. Typical contamination problems and measures for contamination control are discussed as well.

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INTRODUCTION

Food Freezing as a Method for Long-Term Preservation of Perishable Foods

Freezing is one of the paramount industrial methods for long-term preservation of food commodities. Because most of the natural foods contain a large quantity of water, the preservation effect of freezing is due not only to the lower temperatures (as compared with chilled foods) but basically to the phase transition of water into ice crystals. This phase change usually starts at a temperature slightly below 0°C (called ‘initial freezing point’) and continues gradually down to very low (cryogenic) temperatures. Freezing rate is of vital importance. Slow freezing results in large ice crystals, which cause substantial structural damages of the food tissues after thawing, while fast freezing ensures a fine-grain crystal structure with much less structural damages and minimum drip losses after the product is thawed for further processing and consumption (Fikiin, 2003, 2008, 2012).

To achieve such a high freezing rate, special quick freezing systems have been invented and developed, where products are rapidly frozen down to -18°C or to lower temperatures, before placing them in refrigerated rooms for long-term frozen storage (which form part of dedicated industrial facilities called ‘cold stores’ or ‘refrigerated warehouses’). There is not any magic physical meaning in choosing a standard storage temperature of -18°C (except the fact that it corresponds to 0°F and that most water in the stored frozen foods is already turned into ice). While freezing prevents the unwanted microbiological processes by killing or suppressing the spoilage bacteria (except some spore or cold-tolerant forms), product-specific biochemical changes might still occur. As compared with the other long-term preservation methods (canning, drying, freeze-drying, etc.), freezing is the gentlest mode in terms of keeping the natural nutrients and biological value of foods (Fikiin, 2008). A continuous and ubiquitous temperature control must be ensured throughout the entire chain for refrigerated processing, storage, transport, distribution, retail and household handling of frozen foods, which is usually known as ‘cold chain’ or ‘frozen food supply chain’ (Fikiin, 2003, 2012).

Industrial Air Blast Freezing Systems

By circulating air at high speed and low-temperature (most often in the range of -40 to -20°C) around warmer food products, air blast freezers extract heat from these food commodities, thereby freezing them down to the required storage temperature (which is usually -18°C as per the established standard but it might be lower for expensive delicious foods). Fans provide a forced convection, thus ensuring a comparatively high heat transfer coefficient on the product surface and a nearly uniform air temperature throughout the freezer.

Air blast systems for fast freezing force water inside and outside the food cells to freeze rapidly and at almost the same rate. In such a way, fine ice crystals are formed in the whole cellular structure of the food, both in the cell interstices and at the inside of the cells, so that the cells and the tissue structure of the food remain virtually unchanged. Blast freezing allows the food to keep its natural wholesomeness, flavour and texture much better than the other well-known methods for long-term preservation of foods (such as thermosterilization, canning, drying, freeze drying, etc.).

Industrial blast freezers usually employ two-stage vapour-compression refrigeration systems, which make use of mechanical and electrical devices to achieve low temperatures. Such freezers (possess-