Chapter 12
Study of Thermal and Microbiological Behavior of Foods Submitted to Evaporative Cooling Process

Paulo Ricardo Santos da Silva
University of Vale do Rio dos Sinos – Unisinos, Brazil

ABSTRACT

Refrigeration is a widely used technique in the food industry to avoid microbiological spoilage of products. Several variables can affect the performance of chilling process, including the shape and the dimensions of the product, the thermophysical properties of the food and the cooling fluid. The evaporative cooling increases the rate at which the temperature of the products is reduced. However, it makes the refrigeration process more complex, since it involves the simultaneous mass and heat transfer. In this context, numerical simulation is a useful tool to analyze the processes because it allows investigating different operational conditions in a virtual environment, in a quick and inexpensive way. The goal of this chapter was to study the influence of process variables on thermal and microbiological behavior of minimally processed foods submitted to refrigeration process with and without evaporative cooling effect, by means of two case studies.

INTRODUCTION

There is a contemporary trend for people to be increasingly concerned with the nutritional quality of the foods they eat. As part of their efforts to eat healthier diets, many consumers are choosing to purchase products that contain fewer preservatives and are rich in nutrients. In parallel, consumers also desire practical and convenient food preparation (Ahvenainen, 1996; Corbo et al., 2006). Minimally processed fruit and vegetables are a foodstuff that meets the demands of the modern consumer. As a result of these factors, the market for these products has been growing considerably over recent years. For example, Ragaert et al. (2007) claim that from 1999 to 2004 the trade in minimally processed fruit and vegetables in Belgium grew by 57%.

DOI: 10.4018/978-1-4666-8398-3.ch012
From the technological point of view, production of minimally processed fruit and vegetables involves operations that affect their physical integrity, making them more perishable than the raw materials from which they are produced. The production process often involves peeling and chopping operations which cause rupture of cells, leakage of intracellular products (oxidizing enzymes such as polyphenol oxidase), exposure of tissues to the activity of microorganisms responsible for spoilage and acceleration of products’ respiration rates (Ahvenainen, 1996; Corbo et al., 2006; Ragaert et al., 2007; Waghmare et al., 2013). These factors lead to rapid degradation of food products. Therefore, one of the major challenges faced by businesses producing minimally processed fruit and vegetables is to control the mechanisms responsible for deteriorating the quality of their food products, in order to extend shelf life (Corbo et al., 2006).

Storage temperature is one variable that has a direct influence on the time taken for minimally processed fruit and vegetables to spoil. Reducing the temperature of the product slows down the rates of the chemical and biochemical reactions responsible for spoilage and inhibits the activity of microorganisms. As a result, the quality of the food product is maintained for longer, extending its shelf life (Benítez et al., 2012). The literature on food technology includes several studies of the effects of temperature on the quality of minimally processed products (Bhande et al., 2008; Benítez et al., 2012; Waghmare et al., 2013). However, in such studies it has been customary to assume that the product reaches its storage temperature instantaneously. In contrast, in real life, when a food product is stored in a refrigerated system, a certain period of time is required for it to reach thermal equilibrium with the refrigerated environment. This interval of time constitutes a transient period in the chilling process. Its effect on the quality of the final product is a question that has received little attention in the literature. Although this transient period may be relatively short when compared with the total storage time, its effect is not always negligible. For example, studies conducted by Amézquita et al. (2005), Ben Yaghlene et al. (2009), Silva et al. (2013) and Cepeda et al. (2013) demonstrate that the growth of microorganisms on foods is influenced by transient conditions in the cooling process.

Analysis of the influence that conditions during the transient period have on the refrigeration process requires study of the thermal behavior of food products during this process. Such an assessment must be founded on knowledge of the phenomena of heat transfer and thermodynamics. Many different variables can affect the performance of the process, including the shape, dimensions and thermophysical properties of the product, in addition to the thermophysical properties, the flow regime and the velocity of the refrigeration fluid.

Refrigeration of foods can be accomplished with the product already packaged or before packaging. In the second case, the rate at which the temperature of the product is reduced is faster because evaporation of surface humidity contributes to cooling. This phenomenon is known as the evaporative effect. Inclusion of this effect in analyses of food refrigeration processes makes the task more complex, because it involves simultaneous transfer of heat and mass. Numerical simulation of the process is a useful tool in such cases. This approach makes it possible to investigate a range of different ways of conducting the process of food refrigeration in a virtual environment, rapidly and inexpensively.

The objective of this chapter is therefore to demonstrate how the transient conditions of refrigeration processes can impact on the quality of minimally processed fruit and vegetables, illustrating the phenomena involved with two case studies. The first study is a comparison of a variety of different food chilling scenarios employing numerical simulation and investigating the effects of (i) the dimensions and initial temperature of the product; (ii) the temperature and velocity of the refrigeration fluid; and (iii)
Related Content

New Technological Solutions for Recycling Spent Tire Rubber
[www.igi-global.com/article/new-technological-solutions-recycling-spent/62576?camid=4v1a](www.igi-global.com/article/new-technological-solutions-recycling-spent/62576?camid=4v1a)

Analyzing Sustainable Food Supply Chain Management Challenges in India
[www.igi-global.com/chapter/analyzing-sustainable-food-supply-chain-management-challenges-in-india/195222?camid=4v1a](www.igi-global.com/chapter/analyzing-sustainable-food-supply-chain-management-challenges-in-india/195222?camid=4v1a)

Multi-Characteristic Optimization in Wire Electrical Discharge Machining of Inconel-625 by Using Taguchi-Grey Relational Analysis (GRA) Approach: Optimization of an Existing Component/Product for Better Quality at a Lower Cost

Multi-Criteria Decision Making for Optimization of Product Development Under Green Manufacturing Environment