

Infrared Heating in Food Processing: An Overview

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ABSTRACT: Infrared (IR) heating provides significant advantages over conventional heating, including reduced heating time, uniform heating, reduced quality losses, absence of solute migration in food material, versatile, simple, and compact equipment, and significant energy saving. Infrared heating can be applied to various food processing operations, namely, drying, baking, roasting, blanching, pasteurization, and sterilization. Combinations of IR heating with microwave heating and other common conductive and convective modes of heating have been gaining momentum because of increased energy throughput. This article reviews aspects of IR heating and presents a theoretical basis for IR heat processing of food materials and the interaction of IR radiation with food components. The effect of IR on food quality attributes is discussed in the context of samples and process parameters. Applications of IR heating in food processing operations and future research potential are also reviewed.

Introduction

Energy conservation is one of the key factors determining profitability and success of any unit operation. Heat transfer occurs through one of 3 methods, conduction, convection, and radiation. Foods and biological materials are heated primarily to extend their shelf life or to enhance taste. In conventional heating, which is achieved by combustion of fuels or by an electric resistive heater, heat is generated outside of the object to be heated and is conveyed to the material by convection of hot air or by thermal conduction. By exposing an object to infrared (IR) radiation (wavelength of 0.75 to 1000 μm), the heat energy generated can be absorbed by food materials. Along with microwave, radiofrequency (RF), and induction, IR radiation transfers thermal energy in the form of electromagnetic (EM) waves and encompasses that portion of the EM spectrum that borders on visible light and microwaves (Figure 1). Certain characteristics of IR heating such as efficiency, wavelength, and reflectivity set it apart from and make it more effective for some applications than others. IR heating is also gaining popularity because of its higher thermal efficiency and fast heating rate/response time in comparison to conventional heating. Recently, IR radiation has been widely applied to various thermal processing operations in the food industry such as dehydration, frying, and pasteurization (Sakai and Hanzawa 1994).

Food systems are complex mixtures of different biochemical molecules, biological polymers, inorganic salts, and water. The infrared spectra of such mixtures originate with the mechanical vibrations of molecules or particular molecular aggregates within a very complex phenomenon of reciprocal overlapping (Haford 1957). Amino acids, polypeptides, and proteins reveal 2 strong absorption bands localized at 3 to 4 and 6 to 9 μm . On the other hand, lipids show strong absorption phenomena over the entire infrared radiation spectrum with 3 stronger absorption bands situated at 3 to 4, 6, and 9 to 10 μm , whereas carbohydrates yield 2 strong absorption bands centered at 3 and 7 to 10 μm (Sandu 1986; Rosenthal 1992).

IR radiation can be classified into 3 regions, namely, near-infrared (NIR), mid-infrared (MIR), and far-infrared (FIR), corresponding to the spectral ranges of 0.75 to 1.4, 1.4 to 3, and 3 to 1000 μm , respectively (Sakai and Hanzawa 1994). In general, FIR radiation is advantageous for food processing because most food components absorb radiative energy in the FIR region (Sandu 1986).

Over the past several years, IR heating has been predominantly applied in the electronics and allied fields with little practical application in the food processing industry. However, in the last few years significant research efforts have been made in the area of IR heating of foods. The present review is in line with the current developments in the area of IR heating and a base for its widespread upcoming practical applications in food processing. Therefore, the aim of this review is to evaluate existing knowledge in the area of IR heating, provide insight for the relation between product properties and engineering processes, and present an up-to-date view on further research. Along with the sound theoretical background on IR heating, the review also encompasses application of IR heating in food processing operations such as drying, dehydration, blanching, thawing, pasteurization, sterilization, and other miscellaneous food applications such as

MS 20070388 Submitted 5/15/2007, Accepted 8/5/2007. Author Krishnamurthy is with Dept. of Food and Animal Sciences, Alabama A&M Univ., Normal, AL 35762, U.S.A. Authors Khurana and Jun are with Dept. of Human Nutrition, Food and Animal Sciences, Univ. of Huddersfield, Huddersfield, HD 9602, U.S.A. Author Indrayanaj is with Dept. of Agricultural and Biological Engineering, Purdue Univ., West Lafayette, IN 47907, U.S.A. Author Demirci is with Agricultural and Biological Engineering, The Pennsylvania State Univ., University Park, PA 16802, U.S.A. Direct inquiries to author Jun (E-mail: soojin@hawaii.cc.hawaii.edu).

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