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A Numerical Model for Heat Transfer Analysis of Roasting Meat

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Abstract

Heat transfer is estimated during the roasting of meat in microwave. The numerical expression is developed of heat transfer to obtain the desired product, texture, colour and flavour. The conduction process is done in the roasting meat slab. The heat transfer parameters such as thermal conductivity, heat transfer co - efficient of meat slab, surrounding temperature inside the micro oven, desired the processing parameter of meat slab. The temperature measurement devices are already in microwave heating. Hence, the numerical solution for conduction heat transfer equation results in useful method to predict the microwave heating capacity. The simultaneous heat and mass transfers within the microwave equipment. The conduction process of carrying medium is meat slab and their relationship with physical, chemical and biochemical changes are involved. Heat transport in the product will occur through radiation from oven base and forced convection movement of hot moist air flows over the product. Water evaporation will occur through the evaporation from the product to the air. The original characteristics of the product the heat transfer mechanism is finalized and obtained the final product. The result showed that the product temperature is increased and its moisture content will decrease during the roasting process.

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Keywords

Roasting, meat slab, conduction, microwave, heat transfer, moisture loss.

Introduction

A microwave oven (microwave) is an electric oven that heats and cooks food by exposing it to electromagnetic radiation in the microwave frequency range. This induces polar molecules in the food to rotate and produce thermal energy in a process known as dielectric heating. Microwave ovens heat foods quickly and efficiently because excitation is fairly uniform in the outer 25–38 mm (1–1.5 inches) of a homogeneous, high water content food item. Microwave ovens became affordable for residential use in the late 1970s, their use spread into commercial and residential kitchens around the world. In addition to cooking food, microwave ovens are used for heating in many industrial processes. Microwave ovens are a common kitchen appliance and are popular for reheating previously cooked foods and cooking a variety of foods. They rapidly heat foods which can easily burn or turn lumpy if cooked in conventional pans, such as hot butter, fats, chocolate or porridge. Microwave ovens usually do not directly brown or caramelize food, since they rarely attain the necessary temperature to produce Maillard reactions. Exceptions occur in cases where the oven is used to heat frying-oil and other oily items (such as bacon), which attain far higher temperatures than that of boiling water. Microwave ovens have a limited role in professional cooking, because the boiling-range temperatures of a microwave oven will not produce the flavorful chemical reactions that frying, browning, or baking at a higher temperature will. However, such high heat sources can be added to microwave ovens in the form of a convection microwave oven.

Meat is the one highly protein substance with zinc, iron, magnesium, phosphorus and vitamins. In past decades, global meat production and consumption have increased. The preservation of meat is somewhat tedious work, because the spoil by various enzymatic activities. Some other factors also effect the freshness of meat like microbes, temperature etc. It is focussed that preservation of meat is overbearing to prevent the occurrence of deteriorative changes brought by microbial, chemical and physical process. Meat roasting is popular for their unique taste and flavor. Conduction of heating process in meat and microwave radiation significantly contributes for roasting of product.

The analysis of modes of heat transfer in tandoor oven has been reported by (Saxena *et al.*, 1995). The mode of heat transfer is more important than just supplying the required quantity of heat for obtaining the desired product characteristics such as flavor and color. The process of bread preparation is explained by Adler (1958). Baking of biscuits has been stated by standing (1974) and chapati preparation is studied by (Chaudhri and Muller, 1970). The heat transfer during the baking of dosa was studied by Venkateshmurthy *et al.*, 2000. The general heat conduction equation and examine the application of Fourier law of heat conduction to the calculation of heat flow in some simple one-dimensional system. Under the category of one dimensional system several different physical shapes may fall; when the temperature of body is a function only of radial distance and is independent of azimuth angle or axial distance cylindrical and spherical systems are treated as one dimensional. The two dimensional nature the effect of a second space coordinate may be small that it may be neglected and the heat flow problems of multi-dimensional type may be approximated with a one dimensional analysis; in such cases the differential equation are simplified and as a consequence of this simplification much easier solution is available.

Experimental and Mathematical expression

The meat slab is placed in the microwave heating system of thickness of 25mm and having a thermal conductivity of k = 1W/m^{0}c is heated with the help of microwave heating for roasting. The centre temperature of the slab is maintained at 100^{0}c when the surrounding temperature is 30^{0}c. The heat transfer co-efficient on the surface of meat slab is 20W/m^2 ^{0}c. Meat is the one highly protein substances with zinc, iron, magnesium, phosphorus and vitamins. It is focused that preservation of meat is overbearing to prevent the occurrence of deteriorative changes brought by microbial, chemical and physical process.

Thickness of meat slab L = 2 mm = 0.02mm

Thermal conductivity of meat k = 1W/m^{0}c

The centre temperature of slab t_{max} = 100^{0}c

Surrounding temperature t_a = 30^{0}c

The Heat transfer co -efficient h = 20W/m^{0}c

$$t_{max} = t_a + q_g + \left[\frac{L}{2h} + \frac{L^2}{8k}\right]$$

$$100 = 30 + q_g + \left[\frac{0.025}{2x20} + \frac{0.025^2}{8}\right]$$

$q_g =$ 99.573 kW/m^3.

Moisture distribution

Initial moisture is present in the meat product and results in dehydration. In the microoven, the drying rate was determined by evaluation the initial moisture and final moisture. The analysis of thermophysical properties of is based on models developed by various scientist. The quantitatively assessed particular thermophysical property models by relating to a comprehensive experimental thermophysical property data set. Becker and Fricke (1999) and Fricke and Becker (2001, 2002). The ice fraction prediction equation by Chen (1985) and related material developed by Tchigeoy (1979)

The specific heat capacity, the model of Schwartzberg (1976) and specific enthalpy prediction, the Chen (1985) equation, thermal conductivity, the model performed best.

The thermal properties of food and beverages must be involved in designing storage, refrigeration equipment and estimating process times, freezing, heating or drying of food. The thermal properties of foods strongly depend on chemical composition and temperature. The chemical compositions of food are readily available from Holland *et al.,* (1991). Thermal properties of foods can be evaluated by these data in conjunction with temperature based numerical models of thermal properties of individual food. Thermophysical properties often required for heat transfer calculations include density, specific heat, enthalpy, thermal conductivity, and thermal diffusivity.

The thermal properties of food determined by constituents found in foods include water, protein, fat, carbohydrate, fibre and ash is given numerical model for predicting the thermal properties of these components as function of temperature from -40 to 150^{0}c by Choi and Okos (1986).

During baking process, the volume expansion are observed a combined effect of moisture content, temperature and density on thermal properties is given by Baik *et al.,* The interaction between moisture content and density was significant for thermal conductivity as was related between temperature and moisture content on specific heat.

Microwave hating process is heat conduction, convection and radiation process. The quality factors of cooked meat products are based on tenderness, flavour, texture, volume. The process variables are oven temperature, moisture and process time.

The heating is done for physical change, temperature and moisture and chemical reactions to generate final product quality. In addition, the food material properties such as temperature, moisture and process time are taken in account. It is very difficult to measure these properties under these conditions. The challenging of subject to develop, such a heat transfer model which can stimulate the microoven processing of food product.

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