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Ohmic heating: an alternative technology for spices processing

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Abstract

Ohmic heating is an advanced thermal processing method wherein the food material, which serves as an electrical resistor, is heated by passing electricity through it. Electrical energy is dissipated into heat, which results in rapid and uniform heating. Ohmic heating volumetrically heats the entire mass of the food material resulting product of good quality than that of conventional thermal processed. Plant products are most suitable for application of ohmic heating. The inactivation time of peroxidase enzyme during ohmic blanching was less than water blanching. The application of ohmic heating for inactivation of food enzymes and micro-organisms, minimization of nutritional and flavour losses in various fruits and vegetables has been cited by several researchers but there is no literature available related to spice. The ohmic heating especially useful where mechanical agitation to improve heat transfer is not recommended specially in leafy spices. The understanding and exploitation this alternative technology is required for quality processing of the spices.

Key words : Leafy spices, Ohmic heating, spices processing, thermal processing.

Introduction

The ohmic heating (OH) concept is well known and various attempts have been made to use it in food processing. Ohmic Heating technology has gained interest recently because the products are of a superior quality than those processed by conventional technologies (Kim *et al*., 1996; Castro *et al.*, 2003). Moreover, the ohmic heater assembly can be incorporated into a complete product sterilization or cooking process. Among the advantages claimed for this technology are uniformity of heating and improvements in quality with minimal structural, nutritional or organoleptic changes. OH is defined as a process wherein alternating electric current is passed through materials with the primary purpose of heating them. The heating occurs in the form of internal energy transformation from electric to thermal within the material (Sastry and Barach, 2000). The potential applications are very wide and include e.g. blanching, evaporation, dehydration, fermentation, pasteurization and sterilization (Cho *et al*., 1996). When materials contain sufficient water and electrolytes to allow the passage of electric current, Ohmic heating can be used to generate heat within the product (Imai *et al*., 1995). Ohmic processing enables to heat materials at extremely rapid rates. It also enables, under certain circumstances, large particulates and carrier fluids to heat at comparable rates, thus making it possible to use High Temperature Short Time (HTST) and Ultrahigh Temperature (UHT) techniques on solids or suspended materials increasing the final product quality and adding value to products (Parrott, 1992; Kim *et al*., 1996; Castro et al., 2003; Tucker, 2004; Sastry, 2005; Vicente *et al*., 2006). This very desirable scenario is hardly achieved using conventional heating (Lima *et al.*, 1999).The principle of ohmic heating is shown in schematic diagram (Fig. 1). The sample is held between the two electrodes and an insulator cap is also shown near the electrodes. and flow of electricity are shown. The electricity from the power supply flow through the food sample where it acts as a conductor (Bhale, 2004).

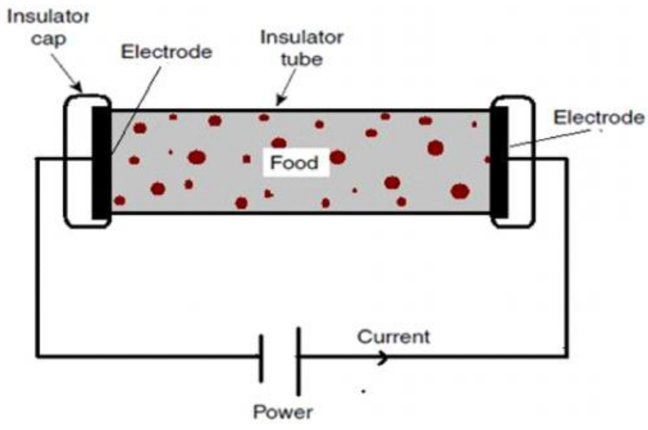

Fig. 1. Schematic diagram of Ohmic Heating

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Application of Ohmic Heating in Food Processing

Ohmic heating is now receiving increasing attention from the food industry and it is being considered an alternative for the indirect heating methods of food processing. Several studies have investigated a number of aspects for the application of ohmic heating within the food industry, for example, rice starch and rice flours (An & King, 2007); extraction of fruit juices (Lima and Sastry 1999a, b; Wang and Sastry 2000); the enhancement of the drying process of sweet potato (Zhong and Lima 2003); stabilization of rice bran (Lakkakula *et al.*, 2004). The utility of ohmic heating in improving the extraction and stability of rice bran oil has been reported by Rao *et al*., (2004). The effect of ohmic heating on lipase activity, phytochemicals and antioxidant activity of rice bran has been investigated by Loypimai *et al.*, 2009. The effect of ohmic heating on enhancement of oil recovery from soybean, mustard and sesame seed has been reported by several researchers (Nema 2006; Pare *et al.,*2012; Kumari *et al*., 2016 and Viswasrao *et al*., 2017). Salengke and Sastry (2007) reported that oil uptake during frying and subsequent cooling of potato slices was decreased by the ohmic pretreatment without involving a liquid medium, the effect was not evident. Juices can be treated to inactivate enzymes without affecting the flavor.

Leadley (2008) has reported that plant products are most suitable for application of ohmic heating. Application of ohmic heating for various fruits and vegetables has been reported by several researchers (Lima & Sastry, 1999b; Lima, *et al.*, 1999; Icier & Ilicali, 2005b; Icier *et al.*, 2008).The application of ohmic heating for inactivation of food enzymes and micro-organisms, minimization of nutritional and flavour losses has been cited by several researchers. Palaniappan *et al.,* (1992) studied the effects of electroconductive heat treatment and electrical pre-treatment on thermal death kinetics of selected microorganisms. Cho *et al.,* (1996) reported the kinetics of inactivation of Bacillus subtilis spores by continuous or intermittent ohmic and conventional heating. Pereira *et al.*, (2007) studied on death kinetics of Escherichia coli. Peroxidases are known to be the most heat stable enzymes in vegetables, and their inactivation is usually used to indicate the adequacy of blanching. Icier *et al.*, (2008) reported that the inactivation time of peroxidase enzyme during ohmic blanching was less than water blanching. Mizrahi *et al.*, (1975) reported that complete peroxidase inactivation was achieved in less than 3 min of current passage as compared to 17 min that was required in the case of boiling water blanching. Castro *et al.*, (2004a) found that lipoxygenase and polyphenoloxidase inactivated at a faster rate during ohmic heating than conventional heating. Similarly, the effects of voltage gradient, temperature, and holding time on the polyphenoloxidase activity were investigated by Icier *et al.,* 2008.

Electroporation Effect

Additionally, to the heating promotion, research data strongly suggests that the applied electric field under OH causes electroporation of cell membranes. The cell electroporationis defined as the formation of pores in cell membranes due to the presence of an electric field and as consequence, the permeability of the membrane is enhanced and material diffusion throughout the membrane is achieved by electro-osmosis. It is assumed that the electric breakdown or electroporation mechanisms dominant for the non-thermal effects of OH (Kulshrestha& Sastry, 2003; Sensoy & Sastry, 2004). Yoon *et al.*, (2002) observed that under OH the electric field appeared to have both direct and indirect effect on the cell wall, and intracellular materials were projectedto the culture medium.

Factors Influencing Ohmic Heating

Sastry (1992) concluded that the most critical property influencing ohmic heating was the electrical conductivity, which depends on several factors: temperature, ionic constituents, material microstructure and field strength. Icier and Ilcali (2005a) found that electrical conductivity of the fruit juices changed with temperature, applied voltage and concentration during ohmic heating of concentrated apple and sour cherry juices. Castro *et al*., (2004a) reported that the electric field has an additional effect on lipoxygenase and polyphenol oxidase inactivation, where much lower D values (i.e. decimal reduction time) where found as compared to conventional heating. Pereira *et al.,* (2007) have observed lower D and z values for the inactivation of E. coli and B. licheniformis when submitted to ohmic heating. This may be due to additional non thermal lethal effect occurred under ohmic heating, due to the presence and effects of the electric current over vegetative cells of E. coli and bacterial spores of B. licheniformis

Kong *et al.,* (2008) reported that the voltage gradient significantly influenced the ohmic heating rates for food materials. The electrical conductivity also changed significantly with temperature.The effect of ohmic heating on oil recovery and quality of sesame and mustard seeds was studied by Kumari *et al*. (2016) and Viswasrao *et al*., (2017). Kumari *et al*., (2016) reported that the optimum value for maximum oil recovery, minimum residual oil content, free fatty acid (FFA) and peroxide value were found as 41.24 %, 8.61 %, 1.74 and 0.86, respectively at

722.52 V/m EFS at EPT 65 °C for 5 min holding time which was obtained by response surface methodology. Viswasrao *et al*. (2017) reported that he maximum oil recovery (84.90 %) was obtained when the sample was heated at 90 °C using electric field strength of 750 V.m-1 for a holding time of 15 min.

Conclusion

Ohmic heating is one of the emerging technologies with the potential applications of this technique for blanching, dehydration and pasteurization in the food industry including spice processing. The ohmic heating especially useful where mechanical agitation to improve heat transfer is not recommended specially in leafy spices. The effects of the applied electric field, the incident electric current and the applied electric frequency during ohmic heating over different microorganisms still need to be more deeply studied as far as spices are concerned. Studies on heating pattern is needed to understand the effects produced by ohmic heating of seed spices. Therefore, understanding, characterizing and modeling this phenomenon is required in order to optimize and possibly exploit its effects for processing of seed spices.

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