ENHENCEMENT OF MASS TRANSFER IN MODEL AND REAL FOOD SYSTEM UNDER LOW VOLTAGE OHMIC HEATING PROCESS

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Introduction

Improvement of mass transfer has numerous potential applications in food processing (Kulshrestha and Sastry, 2003). In meat industry, enhanced mass transfer can be successively applicable in curing process. To reduce the process time, Barat et al. (2005) suggested a simultaneous brine thawing-salting. Many novel processing technologies which are being applied as a drying technology can also increase mass transfer rate. The application of electrical treatment such as pulsed electric field (PEF) and ohmic heating seems to be the most effective method due to electroporation effect or to alternation in membrane permeabilisation (Lebovka et al., 2007; Kulshrestha and Sastry, 2003). In spit of high efficiency of PEF in mass transfer, thawing and sterilisation, the usage of high voltage limits from the safety point of views. Ohmic heating, which are using relatively lower voltage than PEF, can replace an appreciable part of function used in PEF. The most limitation of ohmic treatment for enhancing diffusion is heat generation during processing. It is, thus, necessary to give pulses into ohmic process to prevent heat generation from overall processing. Although numerical researches are dealing with the effect of ohmic heating on food quality, little information is available in enhanced diffusion. This study was aimed to evaluate the effect of low voltage pulsed ohmic treatment on salt diffusion in food system.

Materials and Methods

Porcine *m. longissimus dorsi* was obtained at 24 h post mortem from local abattoir. Meat was cut into rectangular forms (3 × 3 × 6 cm) with their parallel to the fibre direction, and stored at 2ºC for 24 h. For high temperature treatment (HT), two meat samples were tempered at 28ºC for 24 h. Agar gel was prepared with 3% (w/w) agar and 0.18% (w/w) NaCl as a model food system. Gel was put into one side of ohmic apparatus as a 3 cm thickness and matured at 27ºC for 24 h, with the exception of low temperature control (LT) which stored at 2ºC. Brine was adjusted to 2% (w/v) NaCl concentration and stored for 24 h at 2ºC for LT treatment and 28ºC.

LT and ohmic treatments were performed at 2ºC for 200 min, whilst HT treatment at 28ºC. Ohmic treatment was conducted using ohmic system (Figure 1). Pulse was generated by temperature controlling. Temperature of all ohmic treatment was increased by ohmic heating at 20 V until centre of sample reached at 27ºC and decreased by air convection to 19, 22 and 25ºC in O1, O2 and O3 treatment, respectively.

After treatment NaCl concentration was determined following Mohr's method (AOAC, 1990). Measurement was duplicated and the result was analysed using SAS 9.1 and differences among the means were compared using Duncan's Multiple Range test.

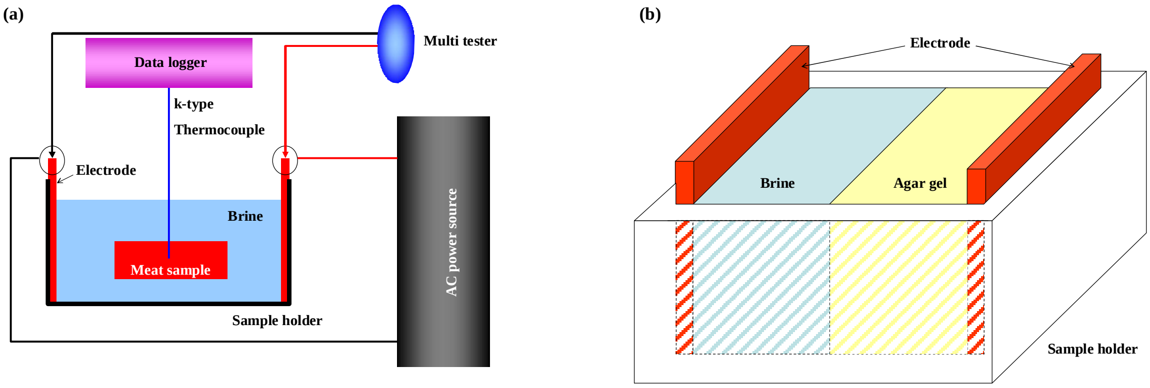

Figure 1. Schematic diagram of the ohmic apparatus for (a) pork meat and (b) agar gel.

Results and Discussion

Diffusion in model food system. Maximum temperature of all ohmic treatment was not exceeded 28ºC at which HT processed (Figure 2). In the current study, decreasing ohmic pulse resulted in improved NaCl diffusion, and the most NaCl diffusion was found at O3 treatment. The result ensured that temperature-dependency of diffusion was eliminated due to lower treatment temperature of ohmic treatment than that of HT treatment. Kemp and Fryer (2007), who determined the effect of alternating electric fields on diffusion, also reported an enhanced diffusion in agar gel. In contrast, Kulshresta and Sastry (2003) suggested that electrical treatment results in no diffusion enhancement when samples had no cell structure. Therefore, this work was proceeded to evaluate the effect of low voltage pulsed ohmic treatment on diffusion in pork meat as real food system.

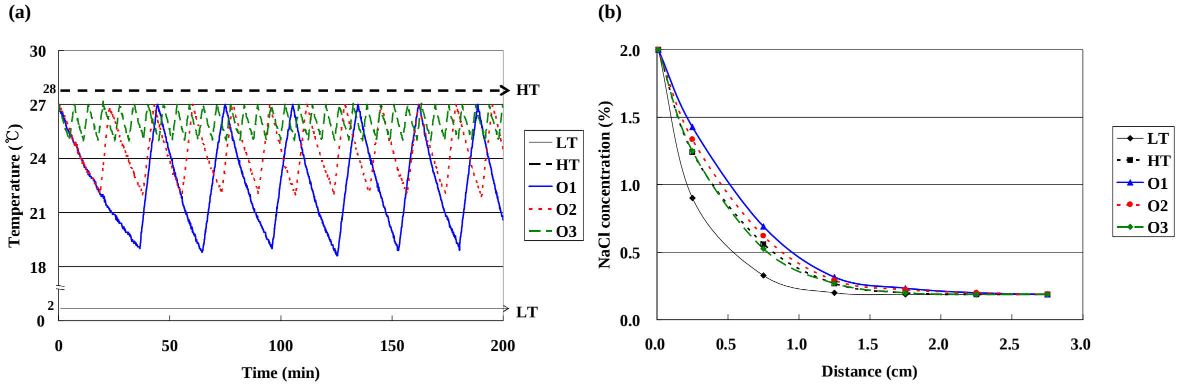

Figure 2. (a) Time-temperature profiles of agar gels during pulsed electric field treatments and (b) NaCl concentration as a function of distance from brine.

Diffusion in real food system. Relatively high temperature processing resulted in significantly high salt concentration ($p<0.05$) as compared LT. No significant differences among ohmic treatments were found ($p>0.05$) whilst decreasing ohmic pulse tended to increase salt concentration of pork meat. However, Kulshrestha and Sastry (2003) postulated that diffusion was proportional to electric field strength. Therefore, higher mass transfer was expected theoretically by increasing voltage level combined with rapid cooling of brine.

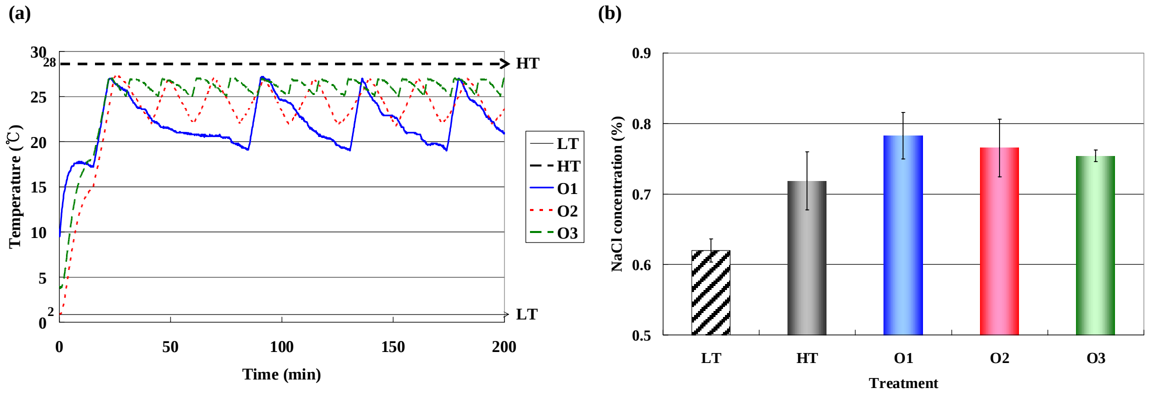

Figure 3. (a) Time-temperature profiles of pork during pulsed electric field treatments and (b) NaCl concentration of pork meat.

Conclusion

Electric treatment was enhanced the diffusion in both model and real food system. Although the mechanism by which diffusion was enhanced under pulsed ohmic treatment was not clear in the current study, applied ohmic processing had a potential application in meat processing. In addition, more effective enhancement could be gained when voltage level and cooling rate was increased, and further research was required to clarify the understanding.

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