LWT - Food Science and Technology 61 (2015) 269–274

Contents lists available at ScienceDirect

LWT - Food Science and Technology

journal homepage: www.elsevier.com/locate/lwt

Effect of ohmic heating on tomato peeling

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ARTICLE INFO

Article history:
Received 19 September 2014
Received in revised form
16 December 2014
Accepted 24 December 2014
Available online 31 December 2014

Keywords:
Ohmic heating
Peeling
Tomato
Field strength
Salt concentration

ABSTRACT

Current industrial methods of tomato peeling are lye and steam peeling, both of which suffer from various disadvantages; caustic, high pH waste with the former, and excessive water use with the latter. In this study, ohmic peeling was attempted to potentially address these problems. Tomatoes were ohmically heated in NaCl solution under various conditions of field strength, initial temperature and number of tomatoes, resulting in peeling with greatly reduced lye concentrations. Field strength, NaCl concentration, initial temperature and fruit concentration all significantly influenced peel cracking time. Results indicated that in terms of quality of peeling, the best conditions of ohmic peeling were: 0.01 g/100 ml NaCl with 8060 and 9680 V/m, and 0.03 g/100 ml NaCl with 6450 and 8060 V/m. These conditions showed potential for processing because they required a reasonably short time (approximately 1 min). Further, the potential to preheat the media to 40 °C or more with reusable media could further shorten the peeling time.

1. Introduction

Lye peeling, one of the most popular tomato peeling methods, involves the use of sodium hydroxide at high concentration (8–25 g/100 g) and temperature (60 to over 100 °C), generating a waste solution with excessively high pH (more than 13), COD, and organic solids (Floros & Chinnan, 1990). The spent lye needs to be neutralized by acid before being released to natural water. It cannot be discarded on the soil because not only does it cause high pH soil which is not conducive to crop growth, but it also prevents bacterial growth, making it impossible to use microbial-based waste treatment ponds. The higher the pH, the more difficult and the less economical it is to treat lye. Moreover, lye peeling waste will clog pores of membrane filters, resulting in fouling and high capital cost (Pandrangi, 1998).

Although lye peeling causes environmental problems, it is still used in the tomato industry in the Midwestern United States because it provides higher quality tomatoes for canning and dicing. This permits the Midwestern tomato industry to compete with the California industry (Pandrangi, 1998).

To lessen environmental effects, industry has tried alternative methods such as low and high pressure steam, vacuum, flame, freezing and dry caustic peeling, but none is as effective as lye peeling, which provides the best quality of final products (Pandrangi, 1998) and reduces the amount of water required for peeling compared to steam peeling.

Meanwhile the California tomato industry has used pressurized steam peeling as an alternative method due to environmental laws and regulations. Even though this method does not cause the serious environmental problems that lye peeling does, it requires a lot of water, high pressure and energy, which increases cost of the final product.

In the recent past, ohmic heating has been used as a method to deliver potentially higher quality products in aseptic processing. It can be used to generate heat uniformly throughout food matrices by controlling the electrical conductivities of food components. Due to its promising advantages, ohmic heating has been expanding to other applications of such as thawing, blanching, extraction and drying. However, to reach its ultimate benefits for new and higher quality products, further insightful research in other applications is warranted.

Because of the promise of ohmic heating in improving mass transfer effects, some studies have investigated ohmic heating for various applications, for example, its potential to increase dye diffusion in beet (Halden, de Alwis, & Fryer, 1990), its capability to extract sucrose from sugar beet (Katrokha, Matvienko, Vorona, Kupchik, & Zaets, 1984), and its possibility to enhance the diffusion of soy milk from soybeans (Kim & Pyun, 1995).

Ohmic heating can improve mass transfer and enhance diffusion by electroporation, which is a process wherein an electric field

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http://dx.doi.org/10.1016/j.lwt.2014.12.053

induces formation of pores in the cell membrane, causing higher mass transfer of liquid components of cells (Coster & Zimmermann, 1975; Dimitrov, 1984; Knorr & Angersbach, 1998; Ohno-Shosaku et al., 1984; Sugar & Neumann, 1984; Zimmermann, Beckers, & Coster, 1977). Lima (1996) reported that the electrical conductivity of food greatly affected the diffusion from food samples. Waveform and frequency significantly affected the effectiveness of mass transfer.

Sensoy (2002) reported that ohmic heating enhanced leaching of solute from mint leaf, a cellular material. Salengke (2000) found reduction of drying time of grape berries by ohmic heating pre-treatment and, at lower frequencies (30 and 60 Hz), cracking of grape skin. This would suggest that there are potential applications in skin removal of other products.

Canned tomatoes are an important product worldwide and in Ohio in particular. Any enhancement would be desirable, especially the improvement of lye peeling to reduce environmental impact. Therefore, we hypothesized that ohmic treatment might be a viable alternative method for tomato peeling. This has proven successful, and is now a patented technology (Wongsa-Ngasri & Sastry, 2009). Indeed, tomatoes could be peeled with or without lye. However, a detailed understanding of optimal treatment conditions is still necessary. The objective of this study was to investigate the effects of electric field strength, NaCl concentration, initial temperature of NaCl, and number of tomatoes on peeling time and peeled tomato quality.

2. Materials and methods

2.1. Experimental setup and procedures

A schematic diagram of the experimental setup is illustrated in Fig. 1. The ohmic heater unit consisted of an open Pyrex glass T-tube cylinder of 0.201 m length and 0.051 m inside diameter. Two titanium electrodes were securely placed at the left and right ends of the T-tube glass via a pair of spacers as in Fig. 2(a), and were connected to an alternating current power supply (0–1000 V). The temperature of the medium was continuously measured by using a Teflon coated type-T thermocouple (Omega Eng. Inc., Stamford, CT) and recorded by a data logger (21X, Campbell Scientific, Inc., Utah).

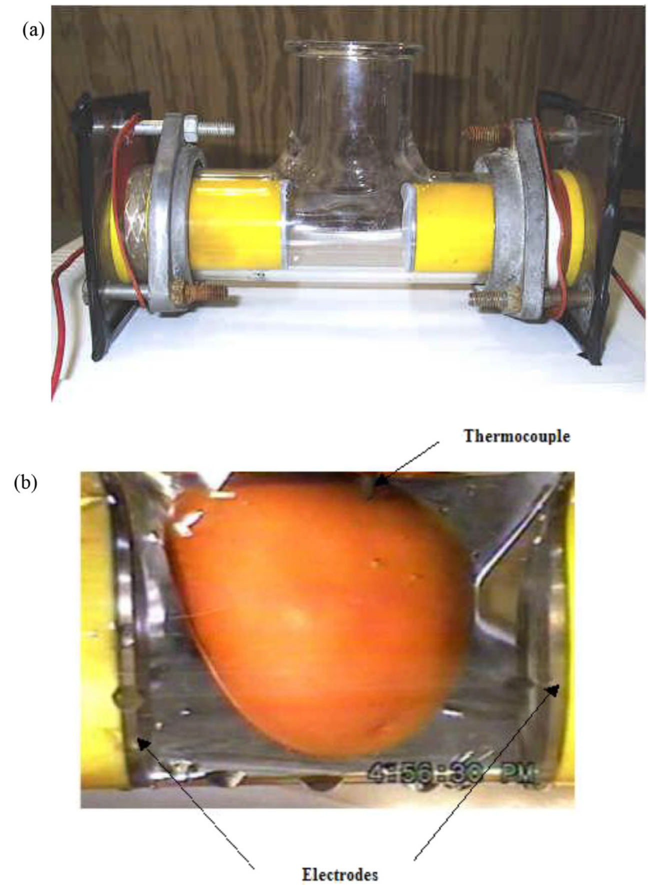

Fig. 2. (a) Ohmic heater unit; (b) unit with a tomato and liquid medium.

A tomato was placed between electrodes, and the residual space filled with the medium. The thermocouple was also placed near the tomato at the same position and depth for every run as seen in Fig. 2(b). Data on voltage, current and time were recorded.

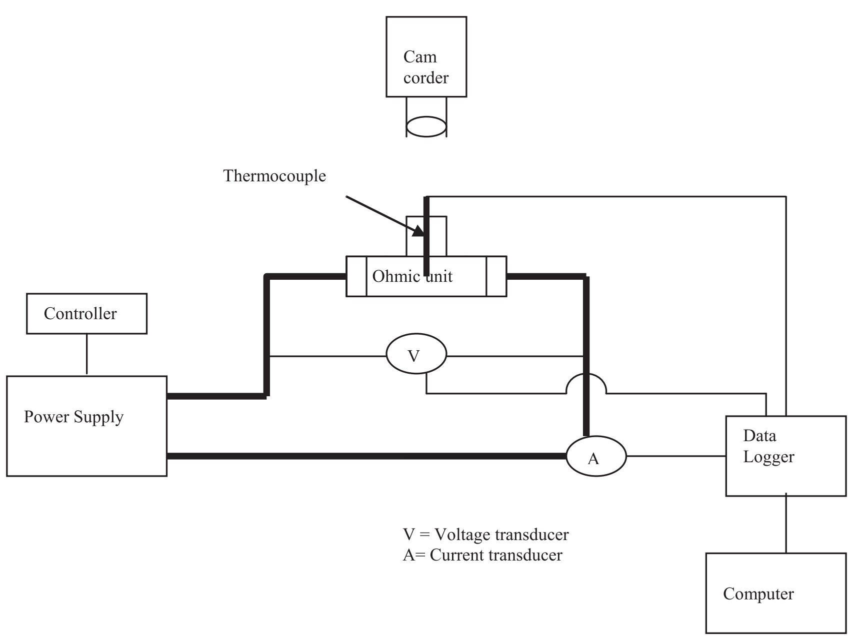

Fig. 1. Schematic diagram of the experiment.