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Investigation of voltage gradient and electrode type effects on processing time, energy consumption and product quality in production of Tomato Paste by ohmic heating

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Introduction

Thermal processing has a huge impact on the textural attribute of the final food product and texture is a major factor contributing the overall quality of food. Ohmic heating is an advanced thermal processing method in which heat is internally generated within foods by passing an alternating electric current through them. Ohmic heating can volumetrically heat the entire mass of a food system, resulting in faster heating, better quality and less energy consumption than conventional thermal processing. Gradient voltage and electrode type have high effect on ohmic heating system.

Materials and Methods

In this study, the effect of voltage gradient and electrode type on moisture reduction time, a/b, ΔE color indexes and energy consumption were studied. For this purpose, four levels of voltage gradients (5, 7, 9 and 11 V cm^{-1}) and four electrode types (Aluminum, Stainless steel, Brass and Graphite) was investigated by ohmic heating in tomato paste processing. Tomato used in this study was purchased from a local market. The whole tomatoes were washed, crushed and mixed in a way that a red less-viscous liquid obtained (Fig. 1). This liquid was considered as tomato samples in the remainder of the article. Ohmic cooking experiments were conducted in laboratory scale ohmic heating system consists of a power supply, a variable transformer, power analyzer, a microcomputer, digital scale (GF-6000) and thermometer (Dual inpur RTD 804U) (Fig. 3). The ohmic cell had a PTF cylinder with an inner diameter of 0.05 m, a length of 0.10 m and two electrodes on both side of the cell. A hole with 3 mm diameter to insert the thermocouple was created and two holes with 5 mm diameter was created on surface of cell. One of them was used for pouring tomato puree and other for exiting steam from cell.

Temperature uniformity was checked during previous heating experiments by measuring the temperatures at different locations in the test cell. Ohmic heating was accomplished till the moisture content of the tomato samples reduced from initial moisture content of as 91(wet basis) to a safer level of 70 (wet basis). Moisture reduction time, a/b and ΔE color indexes, temperature and energy consumption were measured.

Results and Discussion

The results of the nonlinear mathematical model showed that the effect of different voltage gradient levels on moisture reduction time, ΔE parameters and energy consumption had a good agreement ($\alpha \leq 0.01$) as well as voltage gradient had a significant effect on a/b color index ($\alpha \leq 0.05$). Electrode type had significant effect on processing time, ΔE ($\alpha \leq 0.01$), on energy consumption and a/b index ($\alpha \leq 0.05$). Interaction of voltage gradient and electrode type was significant on processing time, energy consumption, a/b and ΔE ($\alpha \leq 0.05$). In all electrodes by increasing the voltage gradient, processing time and energy consumption were reduced. For example by increasing the voltage gradient from 5 to 11 V cm^{-1}, processing time and energy consumption were decreased on average 38% and 23%, respectively. Minimal processing time and minimal energy consumption

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were observed in 11 V cm^{-1} with graphite electrode that were 17 min and 203 kJ, respectively. As well as maximum processing time and maximum energy consumption were obtained in 5V cm^{-1} with aluminum electrode that were 105.21 min and 321 kJ, respectively. But maximum a/b parameter and minimal ΔE index were observed with stainless steel electrode in 11V cm^{-1}. In determining the best electrode, in addition to the processing time and energy consumption, product quality is also an important parameter. However, graphite electrode has better performance in terms of time and energy consumption, but stainless steel electrode has better performance in term of product quality. Since the production of food, quality is an important parameter, and also the two electrodes graphite and steel are similar in terms of energy consumption and processing time, but stainless steel electrode is better in term of quality, so stainless steel electrode is selected for ohmic heating tomato paste.

Conclusions

Different voltage gradients and Electrode type have a significant effect on processing time, energy consumption, ΔE and a/b color indexes. Minimal processing time and minimal energy consumption were observed in 11 V cm^{-1} with graphite electrode that were 17 min and 203 kJ, respectively. But maximum a/b parameter and minimal ΔE index were observed with stainless steel electrode in 11V cm^{-1}. Stainless steel electrode and 11 V cm^{-1} voltage gradient were the best condition for tomato paste processing by ohmic heating.

Keywords: Aluminum, Efficiency, Electricity flow, Graphite, Ohmic cell, Stainless steel