Chapter I

Introduction

Chapter I

INTRODUCTION

Thermal processing is one of the oldest and most extensively used food processing methods for shelf-life enhancement and to ensure microbiological safety of the food products. Fresh fruits are highly perishable in nature due to high water activity therefore, it is necessary to apply some processing technology and convert them in some useful products to extent their shelf-life. Apart from dried and canned, fresh fruits are largely processed into juices, smoothies, purees, nectar etc. and the thermal processing or aseptic processing is commonly used in industry to extent their shelf-life. Thermal processing is applied in many ways in food processing such as blanching, pasteurization, sterilization, thermal drying etc. Blanching, which is applied with an aim to inactivate quality degrading enzymes, as a pretreatment prior to canning, freezing and drying. It helps in retaining color and nutritional characteristics of the product.

The pasteurization and sterilization are carried out as a finishing treatment to perishable foods to enhance the shelf-life by reducing the population of harmful microorganism under the safety margin. Among these the pasteurization is known as mild treatments and sterilization is a severe treatment (in terms of time temperature combination). However, thermal drying extent the shelf life of product by reducing the water content or water activity, with secondary benefits of reducing volume of the product, thereof decreases the cost of packaging, handling, storage and transportation [16].

Conventional thermal processing fundamentally depends on heat transfer by conduction and or convention mechanism, burning of fuels or electric resistive heater is used to produce heat outside the product to be heated [14]. Thereof, large temperature gradient (between the product and heating medium), non-uniform and slow heating during conventional heating process causes quality deterioration of food and additionally make it time and energy deficient. Thus, achieving uniform heating of a product is always a great concern and a major challenge to food processors, therefore modern methods of food processing are being developed to overcome the shortcomings of conventional thermal processing method [14]. The safety and quality of the quality, processing cost, convenience and environmental risks are the major factors considered while developing a novel method of food processing.

Novel methods of food processing are broadly categorized in to two categories viz Non-thermal and Thermal. Non-thermal methods includes pulsed electric field, high pressure processing, violet light/ pulsed light, ultrasound, ozone, cold plasma and oscillating magnetic field etc., whereas novel thermal processing include Microwave heating, Ohmic heating and Infrared heating [1, 7]

Ohmic heating of food material is also reported to be one of the novel thermal food processing method. In this process, the electric current (I) is allowed to flow through a food material as a resistance (R) and its inherent resistance results in ohmic heating ($I^2.R$) and the temperature of the food material raises quickly [5]. The diagramed depiction of OH process is shown in Fig.1. The concept of ohmic (or Joule effect) heating for flowable food materials has existed since the 19th century, however lack of understanding of the basic and fundamental principles resulted in its irregular development. The understanding with time has helped to make successful commercial intrusion of this technology in in Europe and Japan, largely for fruit pieces in syrup or juice; although other products are also under investigation [19]. During the decade of 1993-2013, new improved OH equipment designs have become available. The modern ohmic sterilizers have cut down the process cost 10 times [4].

Ohmic heating heats material rapidly and volumetrically hence, appears to offer an attractive substitute to the conventional thermal processing by minimizing fouling and corrosion, and less damage to the important components of the food material such as flavorings. Ohmic heating has got other advantages over conventional methods of thermal processing such as less damage to rheological, textural, organoleptic and nutritional properties, suitability for particulate foods, besides being energy efficient [9].

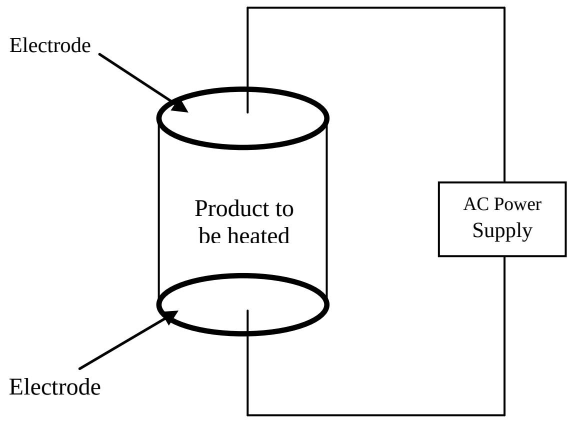

Fig. 1.1 Principle of ohmic heating

The basic parts of an OH equipment include, power supply, electrodes, heating chamber, temperature measurement and controller, transformer, data acquisition system, and computer. Many authors have developed and or designed various designs of OH setup for the research purpose, designs such as heating chambers made of stainless steel lined with teflon tape, Teflon and glass; electrodes of titanium, platinum coated titanium, copper or stainless steel and T-type or K type thermocouples has been widely used [12, 11, 18, 20, 2]. The possibility of adverse electro-chemical reaction, power supply complexity and cost of OH process can be reduced by using low frequency (50-60 Hz) alternating current from domestic power supply.

The meticulous interest in OH technology stems from ongoing food industry interest in aseptic processing of liquid-particulate foods. Conventional aseptic processing systems for particulates rely on heating of the liquid phase which then transfers heat to the solid phase. Ohmic heating apparently put forward an attractive substitute because it heats materials through internal heat generation [17]. During OH the material doesn’t experience too large gradient of the temperature, as occurs in conventional conduction heat transfer, the absence of heating surfaces reduces the chances of fouling thus mixing of burnt particle with the final product can be avoided. Electrical conductivity is one of the key parameter for the applicability of OH process, as most food materials contain sufficient amount of water with dissolved ionic salts which make joules effect possible by conducting the electric current. However there are some exceptions such as oil and fats, sugar rich products etc.

The rate of energy generation during OH also depends on voltage gradient and EC of the material. The EC is the most critical property effecting energy generation, during conventional heating, EC increase sharply with temperature at around 60 °C as a result of break-down of cell wall materials. In case of OH, EC increases linearly with temperature, possibly due to electro-osmotic effect, which could increase the effective conductivity at low temperatures [13]. Since electrical conductivity is related to the concentration of ionic constituents, it is possible to alter porous solid property by infusion of salts. For liquids, EC-temperature relationship is linear regardless of the mode of heating used and electrical conductivity decreases with increasing pulp content, as a result of non-polar constituents in the pulp. The size of the suspended solid has also been shown to affect electrical conductivity, increase in particle size results in the decrease of the electrical conductivity [8].

Mango (*Mangifera indica L.*) is an important source of micro-nutrients, vitamins and other phyto-chemicals as well as other vital food components, which are required for human health. Though it is processed by different methods into various forms; however thermal processing of mango pulp is the most commonly used commercial method. The processed mango pulp is used for preparing beverages, candies, as well as in dairy and confectionery industries. Conventional thermal processing of mango pulp is a time and energy deficient process, which raises the need for the development of a convenient and efficient alternative thermal processing method for mango pulp. Therefore various researchers have studied effects of novel processing methods on mango products such as, High Pressure [10], Pulse Electric Field [21], Ultra-violet Light [6], Cold Plasma [15], Microwave Heat [3] treatment. However to the best of the author's knowledge, very limited literature is available on the OH studies of mango and or mango products. Therefore the present study has been proposed keeping in view the following objectives:

- To design and develop a lab scale ohmic heating setup and its performance evaluation in heating of different fruits.
- To characterize mango puree based on engineering properties (textural, rheological, thermal and ohmic heating) under different levels of TSS and acid content.
- To optimize the process parameters of ohmic heating treatment of mango puree based on inactivation of enzymes and microbes and color change.
- To model the enzyme and microbial inactivation kinetics during ohmic heating of mango puree.
- To evaluate the changes in mango puree characteristics due to ohmic heating upon storage and its comparison with conventional heating.

References

[1] Butz, P., and Tauscher, B. Emerging technologies: chemical aspects. Food research international, 35(2-3), 279-284, 2002.

[2] Castro, I., Teixeira, J. A., Salengke, S., Sastry, S. K., and Vicente, A. A. Ohmic heating of strawberry products: Electrical conductivity measurements and ascorbic acid degradation kinetics. Innovative Food Science and Emerging Technologies, 27-36, 2004.

[2] de Ancos, B., Cano, M. P., Hernandez, A., and Monreal, M. Effects of microwave heating on pigment composition and colour of fruit purees. Journal of the Science of Food and Agriculture, 663-670, 1999.

[4] Ghnimi, S., Flach-Malaspina, N., Dresch, M., Delaplace, G., and Maingonnat, J. F. Design and performance evaluation of an ohmic heating unit for thermal processing of highly viscous liquids. Chemical Engineering Research and Design, 86(6), 626-632, 2008.

[5] Gomes, C. F., Sarkis, J. R., and Marczak, L. D. F. Ohmic blanching of Tetsukabuto pumpkin: Effects on peroxidase inactivation kinetics and color changes. Journal of Food Engineering, 233, 74-80, 2018.

[6] Guerrero-Beltren, J. A., and Barbosa-Cenovas, G. V. Inactivation of Saccharomyces cerevisiae and polyphenoloxidase in mango nectar treated with UV light. Journal of Food Protection, 69(2), 362-368, 2006.

[7] Guillard, V., Mauricio-Iglesias, M., and Gontard, N. Effect of novel food processing methods on packaging: structure, composition, and migration properties. Critical Reviews in Food Science and Nutrition, 50(10), 969-988, 2010.

[8] Icier, F., and Ilicali, C. The effects of concentration on electrical conductivity of orange juice concentrates during ohmic heating. European Food Research and Technology, 220, 406-414, 2005.

[9] Kaur, N., and Singh, A. K. Ohmic heating: concept and applications-a review. Critical Reviews in Food Science and Nutrition, 2338-2351,2016.

[10] Kaushik, N., Kaur, B. P., Rao, P. S., and Mishra, H. N. Effect of high pressure processing on color, biochemical and microbiological characteristics of mango pulp (*Mangifera indica cv. Amrapali*). Innovative Food Science and Emerging Technologies, 22, 40-50, 2014.

[11] Li, L. T., Li, Z., and Tatsumi, E. Determination of starch gelatinization temperature by ohmic heating. Journal of Food Engineering, 62(2), 113-120, 2004.

[12] Marra, F., Zell, M., Lyng, J. G., Morgan, D. J., and Cronin, D. A. Analysis of heat transfer during ohmic processing of a solid food. Journal of Food Engineering, 91(1), 56-63, 2009.

[13] Palaniappan, S., and Sastry, S. K. Electrical conductivities of selected solid foods during ohmic heating. Journal of Food Process Engineering, 14(3), 221-236, 1991

[14] Pereira, R. N., and Vicente, A. A. Environmental impact of novel thermal and nonthermal technologies in food processing. Food Research International, 43, 1933-1946,2010.

[15] Perni, S., Shama, G., and Kong, M. G. Cold atmospheric plasma disinfection of cut fruit surfaces contaminated with migrating microorganisms. Journal of Food Protection, 71(8), 1619-1625, 2008.

[16] Rawson, A., Patras, A., Tiwari, B. K., Noci, F., Koutchma, T., and Brunton, N. Effect of thermal and non thermal processing technologies on the bioactive content of exotic fruits and their products: Review of recent advances. Food Research International, 44(7), 1875-1887, 2011.

[17] Sakr, M., and Liu, S. A comprehensive review on applications of ohmic heating (OH). Renewable and Sustainable Energy Reviews, 39, 262-269, 2014.

[18] Sarang, S., Sastry, S. K., and Knipe, L. Electrical conductivity of fruits and meats during ohmic heating. Journal of Food Engineering, 87(3), 351-356, 2008.

[19] Sastry, S. K., Shynkaryk, M., and Somavat, R. Ohmic and moderate electric field processing: developments and new applications. 11th International Congress on Engineering and Food. Athens, Greece, 2011.

[20] Zareifard, M. R., Ramaswamy, H. S., Trigui, M., and Marcotte, M. Ohmic heating behaviour and electrical conductivity of two-phase food systems. Innovative Food Science and Emerging Technologies, 4(1), 45-55, 2003.

[21] Zhang, Y., and Mittal, G. S. Inactivation of spoilage microorganisms in mango juice using low energy pulsed electric field in combination with antimicrobials. Italian Journal of Food Science, 17(2), 167-176, 2005.