RADIO FREQUENCY HEATING FOR FOOD SAFETY AND PRESERVATION - STATE OF THE ART

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INTRODUCTION

Systems for alternative preservation processes involve bringing a treatment agent into contact with the food product for the period of time needed to reduce the action of deterioration reactions within the product. Radio-frequency (RF) heating offers a solution to this issue, since it uses electromagnetic energy of a longer wavelength than microwaves (MWs), which is of greater industrial interest. The use of radio frequency electric fields (RFEF) as a pasteurization method has been studied for more than 60 years. Microwave pasteurization or sterilization can potentially improve the product quality. But microwave heating is limited to small-sized food packages due to the relatively small penetration depth of microwaves in dielectric materials. This limitation can be overcome by using RF energy. The principles of RF heating are very similar to microwave heating. Heat is generated within dielectric materials, such as foods, when the electromagnetic field reverses the polarization of individual molecules or causes migration of ions within the material as it alternates at high frequency. There has been a long debate over there are non- thermal effects associated with electromagnetic fields. Part of the controversy arose because although reports claimed that pasteurization had been achieved at non-thermal conditions and with low electric field strengths, these assertions could never be replicated (Trujillo and Geveke, 2014). Radio frequency (RF) heating is also considered as a potential postharvest technology for disinfesting legumes.

RADIOFREQUENCY EQUIPMENT

A simple standard parallel plate applicator design is presented schematically in Figure 1. The electrodes are square in shape to ensure adequate temperature distribution in the product mass contained within containers or exposed to air. The shape of the sample plays an important role in the uniformity and extent of RF power distribution when it is placed between fixed gap parallel plate electrodes (Tiwari et al., 2011). In this design, the lower electrode is chosen as the high-voltage electrode because the assembly is mounted directly over the matching box, thus making the connection as short as possible. The electrodes are connected to the RF voltage via thin, silver plated copper strips. Access to the electrodes is made simple through a hinged cover on the top of the cabinet. Electrode spacing is ensured through the use of Teflon columns. The radiating qualities of the installation are limited by ensuring that the applicator is contained within in a metal cabinet enclosure maintained at ground potential (Orsat and Raghavan, 2014).

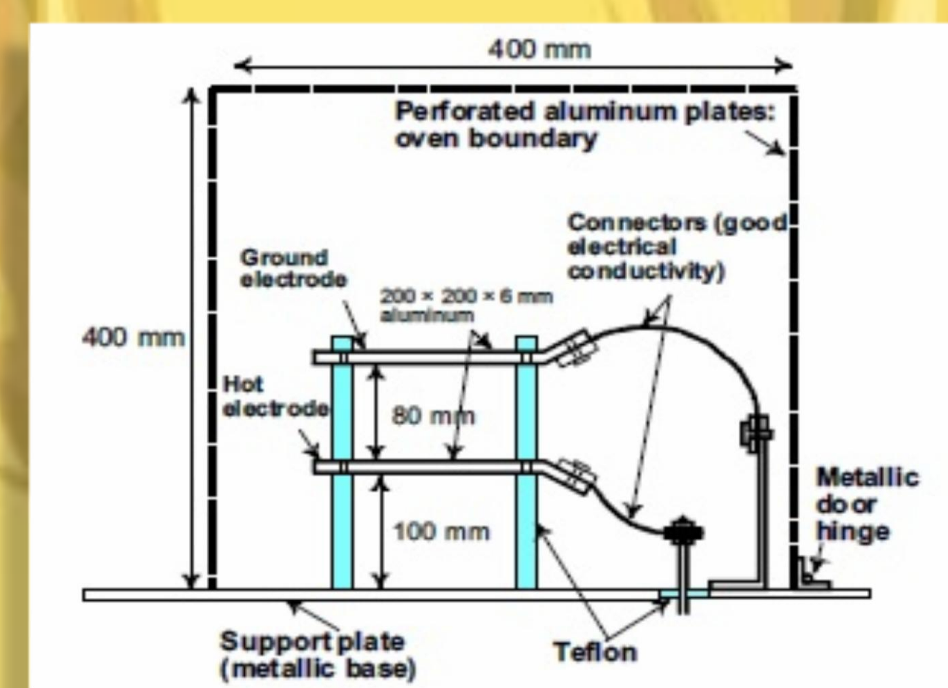

Figure 1. Schematic view of a typical parallel plate applicator with connections and protective grounded cover (Orsat and Raghavan, 2014)

INACTIVATION MECHANISM

The mechanism of radio frequency heating relates to the fact that the molecules within a product placed in an RF environment re-orient themselves continuously (27 million times/s at 27 MHz) in response to the applied field (dipole heating). This response initiates volumetric heating within the entire product due to frictional interaction between the molecules. Radio frequency heating is accomplished through a combination of dipole heating and electric resistance heating resulting from the movement of dissolved ions present in the food. Although identical to the microwave in terms of its heating characteristics, radio frequency has the added advantage of uniform heating in homogeneous foods, and most important of all, high penetration depth that could be used to pasteurize or sterilize liquid products.
Microbial inactivation is based on electroporation of cell membranes, causing reversible or irreversible pore formation depending on the electric field intensity (Palgan et al., 2012) When a cell is exposed to an external electric field, charge is accumulated on the cell membrane resulting in an artificial increase of the transmembrane potential (TMP). If such TMP increase is large enough, and sustained for long enough, cell membrane permeability to ions and macromolecules will increase very significantly (González-Sosa et al., 2014).

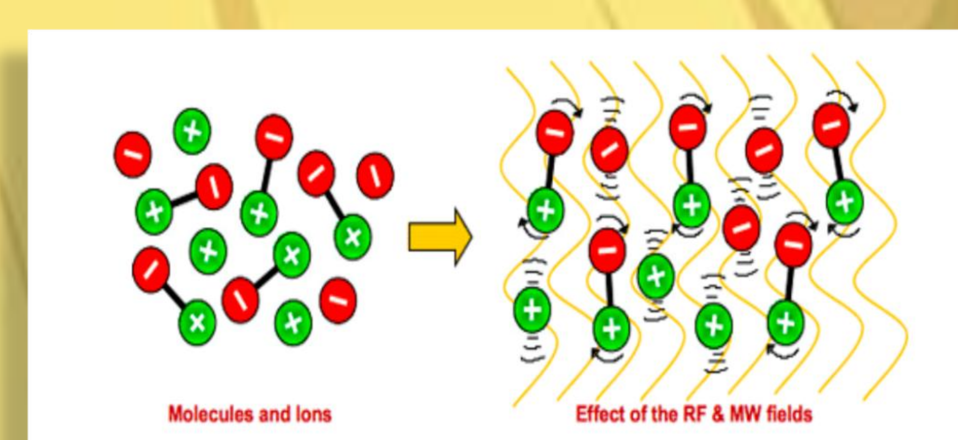

Figure 2. Dipole heating (http://www.stalam.it/)

RADIOFREQUENCY APPLICATIONS

- Microbial and pest reduction by dielectric heating has been studied in many experiments, including meat and meat products; poultry; eggs and egg products; fish and shellfish; fruit and vegetable products such as canned fruit, fruit juice, and jam; soy milk; sugar beet molasses; pea protein concentrates; ready-cooked meals; milk and its products; puddings; cereals; breads; cakes; pasta; starch; and spices.
- Radio frequency dielectric heating is now widely used in industrial applications such as drying textile products (spools, rovings, and skeins), final drying of paper, final dehydration of biscuits at outlets of baking ovens, and melting honey.
- Radio frequency (RF) technology has been explored in various food processing operations, such as pasteurization and sterilization and insect disinfestations in various agricultural commodities, such as fresh fruits and dry nuts.

CONCLUSIONS

- As a rapid heating method, RF heating offers a considerable speed advantage over conventional heating methods, particularly in solid foods in which heat transfer is predominantly governed by heat conduction. Even with this major advantage and the fact that this technology has been available for many years, its uptake by industry have been relatively slow.
- More research is needed, however, to evaluate the mechanisms of action of each treatment on the main pathogens found in each type of food. More research is also needed to evaluate the potential of radiofrequency treatment to reduce bacterial contamination in foods, especially bakery products, and its impact on quality attributes.

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SELECTIVE REFERENCES

Mitelut, A., Popa, M., Geicu, M., Niculita, P., Vatuiu, D., Vatuiu, I., Gilea, B., Balint, R., Cramariuc, R. 2011. Ohmic treatment for microbial inhibition in meat and meat products. Romanian Biotechnological Letters, 16 (1), 149-152.
Trujillo, F. J., Geveke, D. J. 2014. Nonthermal Processing By Radio Frequency Electric Fields. Emerging Technologies for Food Processing (Second Edition), 259–269.
Orsat V., Raghavan G.S.V. 2014. Radio-Frequency Processing. Emerging Technologies for Food Processing (Second Edition), 385–398.