

UNCONVENTIONAL TREATMENTS OF FOOD: MICROWAVE vs. RADIOFREQUENCY

Georgiana-Aurora ȘTEFĂNOIU (APOSTOL), Elisabeta Elena POPA, Amalia
Carmen MITELUȚ, Mona Elena POPA

*University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Mărăști
Blvd, District 1, 011464, Bucharest, Romania



The International Conference of the University of Agronomic
Sciences and Veterinary Medicine of Bucharest

AGRICULTURE FOR LIFE, LIFE FOR AGRICULTURE
June 8 – 10, 2017, Bucharest, Romania



TABLE OF CONTENTS

1.INTRODUCTION

2.EQUIPMENT REQUIRED FOR MW AND RF HEATING

3.MECHANISM OF MW AND RF HEATING

**4.FACTORS THAT AFFECTING MICROWAVE AND
RADIOFREQUENCY HEATING**

5.APPLICATIONS OF MW AND RF HEATING

6.CONCLUSIONS



The International Conference of the University of Agronomic
Sciences and Veterinary Medicine of Bucharest

AGRICULTURE FOR LIFE, LIFE FOR AGRICULTURE
June 8 – 10, 2017, Bucharest, Romania



OBJECTIVE

The aim of this paper is to make a short review in respect to unconventional treatments of food, which are already implemented in industry or are in the research and development phase and to present similarities and differences between two novel treatments: microwave (MW) and radiofrequency (RF) in terms of equipment required, mechanism of action and applications in food industry.



The International Conference of the University of Agronomic
Sciences and Veterinary Medicine of Bucharest

AGRICULTURE FOR LIFE, LIFE FOR AGRICULTURE
June 8 – 10, 2017, Bucharest, Romania



INTRODUCTION

- ④ The market pressure to produce ever-tastier, ever-cheaper, low- and no-fat, chemical-free, safe products is one of the strongest trends in the food industry ([Orsat and Raghavan, 2014](#)).
- ④ Consumers now expect food products of superior sensory quality and increased functional and nutritional properties, combined with a traditional, wholesome image and guaranteed safety ([Nychas and Panagou, 2011](#)).



The International Conference of the University of Agronomic
Sciences and Veterinary Medicine of Bucharest

AGRICULTURE FOR LIFE, LIFE FOR AGRICULTURE
June 8 – 10, 2017, Bucharest, Romania



INTRODUCTION

- ④ In the last ten years, there are limitations in the microbial decontamination of foods by current methods and the development of novel techniques in this area would be advantageous.
- ④ Conventional cooking and heating techniques produce the degradation of the product's quality attributes and nutritional properties due to the intense heat treatment and subsequent destruction of proteins and vitamins, including undesirable changes to other characteristics such as flavour and colour. Dielectric heating has been studied in many experiments for microbial and pest reduction and for the ability to heat the product without making undesirable changes.



The International Conference of the University of Agronomic
Sciences and Veterinary Medicine of Bucharest

AGRICULTURE FOR LIFE, LIFE FOR AGRICULTURE

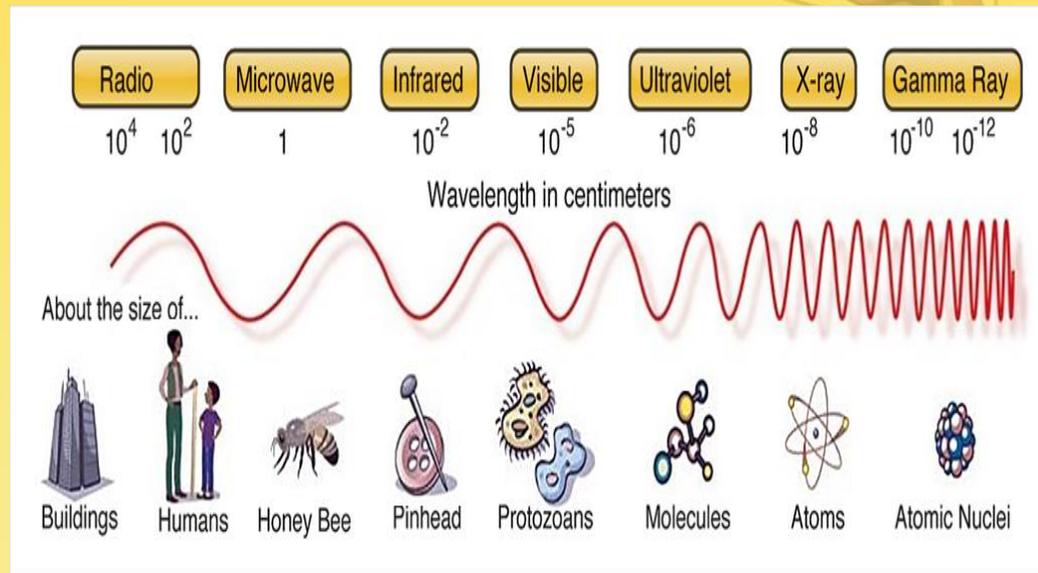
June 8 – 10, 2017, Bucharest, Romania



INTRODUCTION

MW

- 915 MHz;
- 2,450 MHz.



RF

- 13.56 MHz;
- 27.12 MHz;
- 40.68 MHz.

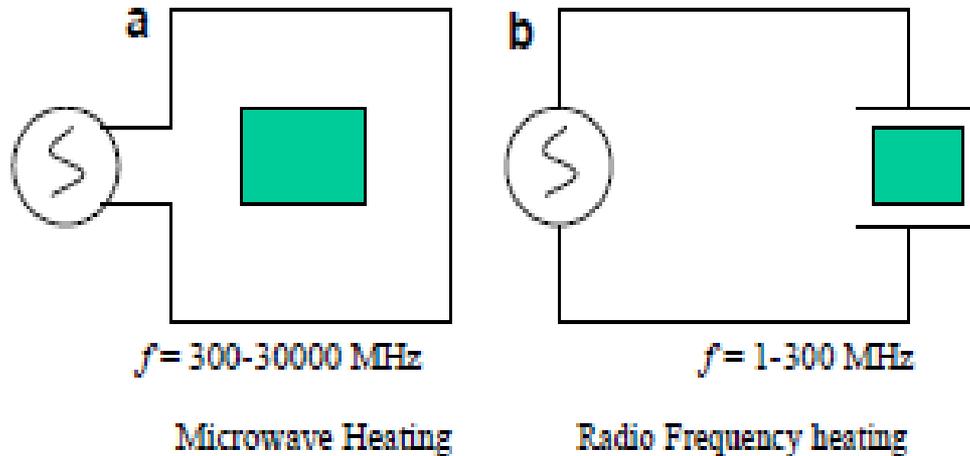


The International Conference of the University of Agronomic
Sciences and Veterinary Medicine of Bucharest

AGRICULTURE FOR LIFE, LIFE FOR AGRICULTURE
June 8 – 10, 2017, Bucharest, Romania



EQUIPMENT REQUIRED FOR MW AND RF HEATING



Schematic arrangement for (a) MW and (b) RF heating (Marra et al., 2009)

A typical MW system consists of a magnetron, a waveguide and an applicator cavity. The magnetron generates MW and the waveguide carries the waves to the applicator cavity. The material is kept in the applicator cavity (Dev et al., 2012).

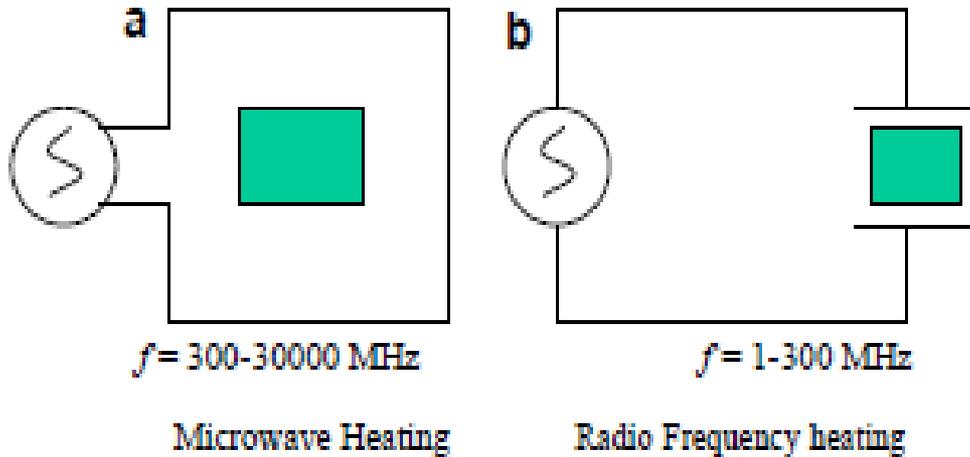


The International Conference of the University of Agronomic Sciences and Veterinary Medicine of Bucharest

AGRICULTURE FOR LIFE, LIFE FOR AGRICULTURE
June 8 – 10, 2017, Bucharest, Romania



EQUIPMENT REQUIRED FOR MW AND RF HEATING



RF

The target material to be heated is placed between but, not touching the parallel electrodes.

Schematic arrangement for (a) MW and (b) RF heating (Marra et al., 2009)

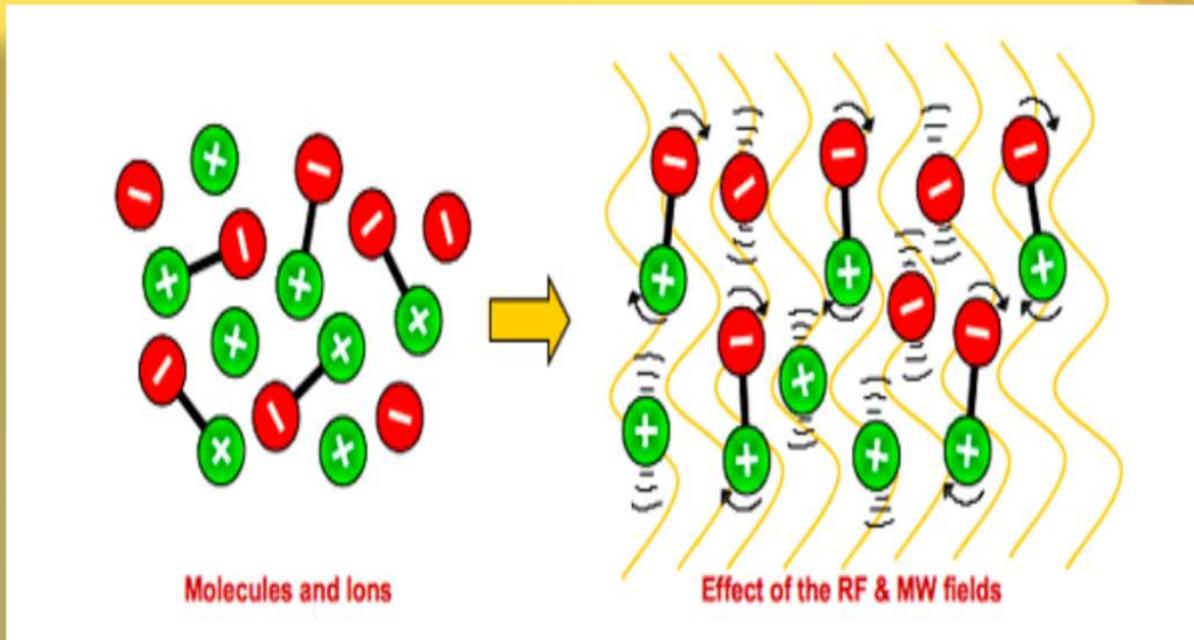


The International Conference of the University of Agronomic Sciences and Veterinary Medicine of Bucharest

AGRICULTURE FOR LIFE, LIFE FOR AGRICULTURE
June 8 – 10, 2017, Bucharest, Romania



MECHANISM OF MW/RF HEATING



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.



The International Conference of the University of Agronomic Sciences and Veterinary Medicine of Bucharest

AGRICULTURE FOR LIFE, LIFE FOR AGRICULTURE
June 8 – 10, 2017, Bucharest, Romania



FACTORS THAT AFFECTING MICROWAVE AND RADIOFREQUENCY HEATING

Dielectric properties

- The dielectric property most important in the microwave and radiofrequency heating of foods is the ratio of the dielectric properties expressed as ratios of the dielectric properties of free space. This gives the relative dielectric constant and relative dielectric loss factor.
- The relative dielectric constant governs the amount of incident power absorbed or reflected while dielectric loss factor measures the amount of absorbed energy dissipated or transmitted within the food (Tewari and Juneja, 2007; Marra et al., 2009, Puligundla et al., 2013; Hou et al., 2016).



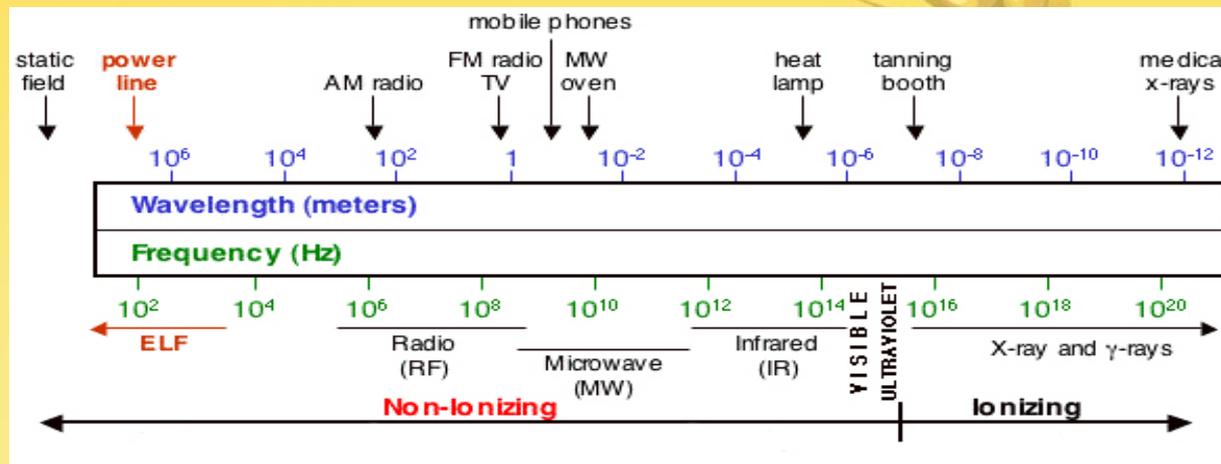
The International Conference of the University of Agronomic
Sciences and Veterinary Medicine of Bucharest

AGRICULTURE FOR LIFE, LIFE FOR AGRICULTURE
June 8 – 10, 2017, Bucharest, Romania



FACTORS THAT AFFECTING MICROWAVE AND RADIOFREQUENCY HEATING

Frequency



The electromagnetic spectrum (Ibrahim et al., 2012)



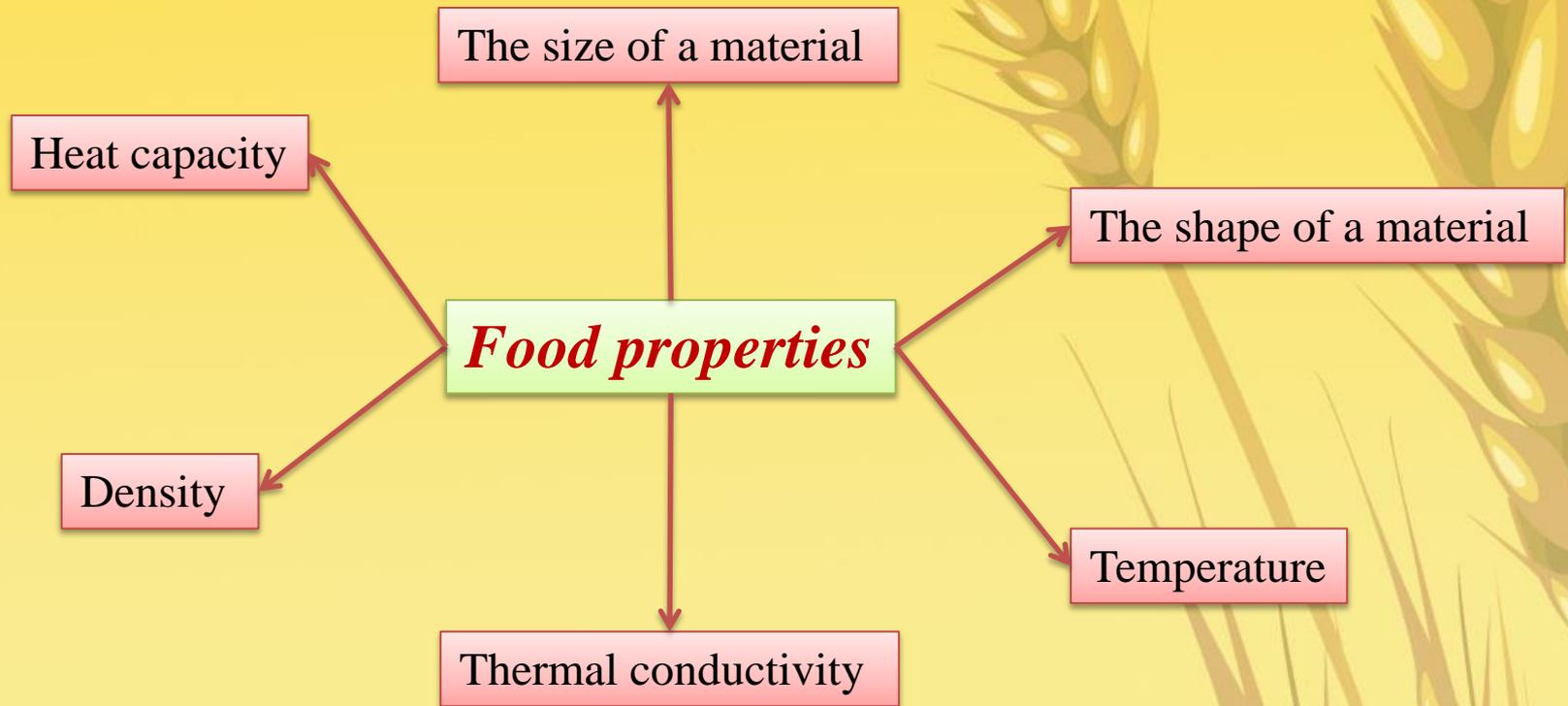
The International Conference of the University of Agronomic Sciences and Veterinary Medicine of Bucharest

AGRICULTURE FOR LIFE, LIFE FOR AGRICULTURE

June 8 – 10, 2017, Bucharest, Romania



FACTORS THAT AFFECTING MICROWAVE AND RADIOFREQUENCY HEATING



The International Conference of the University of Agronomic Sciences and Veterinary Medicine of Bucharest

AGRICULTURE FOR LIFE, LIFE FOR AGRICULTURE

June 8 – 10, 2017, Bucharest, Romania



FACTORS THAT AFFECTING MICROWAVE AND RADIOFREQUENCY HEATING

Temperature and moisture content

- Both temperature and moisture content can change during heating and, therefore, those may have a combined effect on the dielectric constant, dielectric loss factor, loss tangent, and subsequently on the heating behaviour (**Ahmed and Ramaswamy, 2007**).
- The temperature of food products should be controlled or known for adjusting the treatment equipment, to obtain uniform final temperatures or for setting the time of treatment. In many cases is recommended to preheating the food products to avoid, in this way, the condensation phenomena.



The International Conference of the University of Agronomic
Sciences and Veterinary Medicine of Bucharest

AGRICULTURE FOR LIFE, LIFE FOR AGRICULTURE
June 8 – 10, 2017, Bucharest, Romania



APPLICATIONS OF MW AND RF HEATING



The International Conference of the University of Agronomic
Sciences and Veterinary Medicine of Bucharest

AGRICULTURE FOR LIFE, LIFE FOR AGRICULTURE

June 9 – 11, 2016, Bucharest, Romania



APPLICATION OF MW AND RF HEATING

- △ Microwave heating has vast applications in the field of food processing over a period of several decades. The applications of microwave heating in food processing include drying, pasteurization, sterilization, thawing, tempering, baking of food materials etc. (Gupta and Wong, 2007; Chandrasekaran et al., 2013; Ozkoc et al., 2014).
- △ The microbial treatment under microwaves irradiation is a function of power, frequency range, time and temperature. The technique using fixed frequency microwaves has been used in the pasteurization of milk, yoghurt and dairy products and had an effect on reducing the bacterial count and deactivating enzymes at a lower energy input level and destruction as compared with conventional means of pasteurization techniques in use (Lamb and Siores, 2010; Michael et al., 2014).



APPLICATION OF MW AND RF HEATING

- △ Wu and Yao (2010) investigated the survivals of both lab-generated and environmental bio-aerosols when exposed to the microwave irradiation (2450 MHz) for 2 min at different output powers (700, 385 and 119W). As a result of the study, the survival rates of *Bacillus subtilis* var niger, *Pseudomonas fluorescens* and *Aspergillus versicolor* was lower.
- △ Banana slices were dehydrated by microwave vacuum (MWVD), a microwave multi-flash drying process (MWMFD) and freeze drying. The results show that it is possible to create dried-and-crisp fruits by applying successive cycles of heating and vacuum pulses in a microwave field. The MWMFD process is more effective than the MWVD process for producing dried and-crisp bananas, with very short drying times when compared to freeze-drying times (Monteiro et al., 2016) .



APPLICATION OF MW AND RF HEATING

-  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.
-  Bottled juices including peach, quince and orange moving through an RF applicator offered better bacteriological and sensorial qualities than juices treated by conventional thermal processing methods ([Wang et al., 2003](#)).
-  RF heating can be applied to control pathogens in peanut butter products without affecting quality ([Guo et al., 2006](#)).



The International Conference of the University of Agronomic
Sciences and Veterinary Medicine of Bucharest

AGRICULTURE FOR LIFE, LIFE FOR AGRICULTURE
June 8 – 10, 2017, Bucharest, Romania



APPLICATION OF MW AND RF HEATING

-  Radio-frequency heating, coupled with appropriate packaging, can improve the storability of repacked hams by reducing the bacterial load, reducing moisture loss and maintaining an overall greater product sensory quality and acceptance (Orsat et al., 2004).
-  RF treatment was also investigated in naturally infected fruit where the *Monilinia* spp. development was completely inhibited in both ‘Summer Rich’ and ‘Placido’ peaches. No brown rot control was observed in nectarine fruit artificially inoculated or with natural inoculum (Casals et al., 2010).



The International Conference of the University of Agronomic
Sciences and Veterinary Medicine of Bucharest

AGRICULTURE FOR LIFE, LIFE FOR AGRICULTURE

June 9 – 11, 2016, Bucharest, Romania



APPLICATION OF MW AND RF HEATING

-  The non-thermal process of radio frequency electric fields (RFEF) has been shown to inactivate bacteria in apple juice at moderately low temperatures, but has yet to be extended to inactivate bacteria in orange juice. No loss in ascorbic acid or enzymatic browning was observed due to RFEF processing (Geveke et al., 2007).
-  Heating bread to 58°C or higher resulted in 4-log reduction of *P. citrinum* spores isolated from moldy bread. The storage life at room temperature (23°C) was extended by 28 ± 2 days for the treated white bread (Liu et al., 2010).



CONCLUSIONS

MW HEATING

ADVANTAGES

- (i) the time required to come up to the desired process temperature is shorter;
- (ii) the heat is generated in the product rapidly and uniform, which means that small heat conductivities or heat transfer coefficients do not play an important role in the heating process;
- (iii) it can be turned on or off instantly;
- (iv) the product can be pasteurized after being packaged;
- (v) the systems are space saving, or they provide reduced noise levels.

DISADVANTAGES

the lack of experimental data needed to model MW heating.



The International Conference of the University of Agronomic
Sciences and Veterinary Medicine of Bucharest

AGRICULTURE FOR LIFE, LIFE FOR AGRICULTURE
June 8 – 10, 2017, Bucharest, Romania



CONCLUSIONS

RF HEATING

ADVANTAGES

- (i) there is no need for electrodes contacting the food
- (ii) due to the longer wavelength of RF, its power will penetrate more deeply in the foods as compared to microwave power;
- (iii) the construction of large RF heating systems is simpler than their microwave counterparts, and their application to continuous processes is straightforward;
- (iv) it is a technology particularly suited to large industrial applications.

DISADVANTAGES

- (i) the higher equipment and operating costs for an equivalent power output
- (ii) the reduced power density when compared to microwave heating, meaning that larger RF heating systems are needed for the same power rating and also that slower heating rates are achieved with RF as compared to microwaves;
- (iii) the determination of food RF dielectric properties



CONCLUSIONS



In fact, RF and MW heating has been successfully applied in the food industry for drying, baking and meat thawing, but controversial data are present on the effect of MW or RF on biological systems.



The International Conference of the University of Agronomic
Sciences and Veterinary Medicine of Bucharest
AGRICULTURE FOR LIFE, LIFE FOR AGRICULTURE
June 8 – 10, 2017, Bucharest, Romania



ACKNOWLEDGEMENTS

This paper was published under the frame of Partnerships in priority areas Programme, PCCA Contract no. 164 / 2014, RAFSIG.

<http://rafsig.usamv.ro/>



The International Conference of the University of Agronomic
Sciences and Veterinary Medicine of Bucharest

AGRICULTURE FOR LIFE, LIFE FOR AGRICULTURE
June 8 – 10, 2017, Bucharest, Romania



SELECTIVE REFERENCES

- Awuah G.B., Ramaswamy H.S., Economides A., Mallikarjunan K., (2005). Inactivation of *Escherichia coli* K-12 and *Listeria innocua* in milk using radio frequency (RF) heating. *Innovative Food Science and Emerging Technologies*, 6, 396 – 402.
- Casals C., Viñas I., Landl A., Picouet P., Torresa R., Usalla J., (2010). Application of radio frequency heating to control brown rot on peaches and nectarines. *Postharvest Biology and Technology*, 58, 218–224.
- Geveke D. J., Kozempela M., Scullena O. J., Brunkhorst C., (2002). Radio frequency energy effects on microorganisms in foods. *Innovative Food Science and Emerging Technologies*, 3 (2), 133–138.
- Liu Y., Tang J., Mao Z., Mah J.H., Jiao S., Wang S., (2010). Quality and mold control of enriched white bread by combined radio frequency and hot air treatment. *Journal of Food Engineering*, 104, 492–498.
- Marra F., Zhang L., Lyng J.G., 2008. Radio frequency treatment of foods: Review of recent advances. *Journal of Food Engineering* 91, 497–508.
- 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.
- Orsat V., Raghavan G.S.V., (2014). Radio-Frequency Processing. *Emerging Technologies for Food Processing (Second Edition)*, 385–398.
- Trujillo F. J., Geveke D. J., (2014). Nonthermal Processing By Radio Frequency Electric Fields. *Emerging Technologies for Food Processing (Second Edition)*, 259–269.
- Uemura K., Takahashi C., Kobayashi I., (2010). Inactivation of *Bacillus subtilis* spores in soybean milk by radio-frequency flash heating. *Journal of Food Engineering*, 100, 622–626.



The International Conference of the University of Agronomic
Sciences and Veterinary Medicine of Bucharest

AGRICULTURE FOR LIFE, LIFE FOR AGRICULTURE

June 8 – 10, 2017, Bucharest, Romania



THANK YOU FOR YOUR ATTENTION!



The International Conference of the University of Agronomic
Sciences and Veterinary Medicine of Bucharest

AGRICULTURE FOR LIFE, LIFE FOR AGRICULTURE
June 8 – 10, 2017, Bucharest, Romania

