THE DISTRIBUTION OF ELECTRIC FIELD AT DRYING CHESTNUTS FLOUR IN A MICROWAVE FIELD

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Abstract

In the present study, was developed using the commercial software Ansoft HFSS (High Frequency Structure Simulation) a numerical modeling of a microwave system having as a dielectric material the Chestnut flour . Using numerical modeling can be simulated dielectric products to test appropriate microwave treatment strategies for pest and homogeneous drying flour chestnut.

Key words: Ansoft HFSS, microwave drying, dielectric properties, numerical modeling, flour chestnut

INTRODUCTION

Chestnut (Castanea mollissima) is one of the most popular nuts in the world with a unique flavour and taste. (Wenchuan Guo at all 2011). The chestnut has relatively high moisture content and is rich in carbohydrate and low in fat, and thus it is susceptible to insect damage (Wenchuan Guo at all 2011). The disadvantages of conventional thermal disinfestation method include a slow heating rate, a long processing time and non-uniform temperature distribution. It is therefore recommended microwave field processing of dielectric materials has become an important and developed technology used in a large area of applications. Due to the complex interaction phenomenons of the microwave field within the materials, the success of these applications requires knowledgements on material properties and also on the way that processing equipments are being designed. Many researchers have demonstrated that dielectric heating with microwave energy can overcome the shortcomings of conventional thermal treatments for postharvest disinfestations (Ikediala, Tang, Drake, & Neven, 2000; Lagunas-Solar et al., 2007; Nelson, 1996; Wang et al., 2001, 2007a, 2007b).

MATERIAL AND METHOD

Permittivity describes dielectric properties that influence reflection of electromagnetic waves at interfaces and the attenuation of the wave energy within materials.

The complex relative permittivity ε^* of a material can be expressed in the following complex form:

$\varepsilon^{"} = \varepsilon' - j\varepsilon''$ (1)

The real part ε', is referred to as the dielectric constant and represents stored energy when the material is exposed to an electric field, while the dielectric loss factor ε'', which is the imaginary part, influences energy absorption and attenuation, and $j = \sqrt{-1}$. Mechanisms that contribute to the dielectric loss in heterogeneous mixtures include polar, electronic, atomic and Maxwell–Wagner responses (Metaxas & Meredith, 1993, S. Wang et al 2003). At microwave frequencies of practical importance and currently used for applications in material processing (microwave frequencies of 915 and 2450 MHz), ionic conduction and dipole rotation are the dominant loss mechanisms (Ryynänen, 1995):

$\varepsilon'' = \varepsilon''_d + \varepsilon''_\sigma$ (2)

where subscripts d and σ stand for contributions due to dipole rotation and ionic conduction, respectively; σ is the ionic conductivity (S m^{-1}) of a material, f is the frequency (Hz), and ε_0 is the permittivity of free space or vacuum (8.854×10^{-12} F m^{-1}). Dielectric lossy materials convert electric energy microwave frequencies into heat. (S. Wang et al 2005). For the numerical simulation of the heating process was used Ansoft HFSS program. The software package Ansoft HFSS (High Frequency Structure Simulator) is an interactive software that allows the determination of the electric field within the passive structures at high frequencies. Post-processing software includes commands useful to analyze in detail the functioning of the structures considered.

The heating in the microwave field is undergoing tests with two waveguides with dimensions:

- Guide with interior width of 30 X 90 [mm] which was introduced several radiating slots
- Guide with interior width of 10 x 90 [mm] without radiating slots

Two practical cases are considered:

a) If the in guide was introduced several radiating slots;

b) If the user has not introduced several radiating slots.

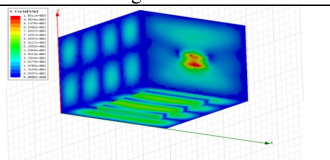
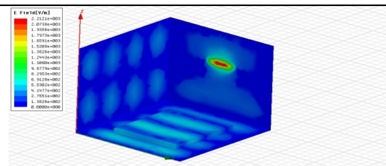
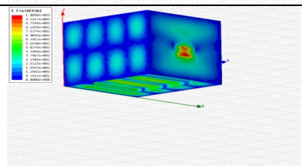
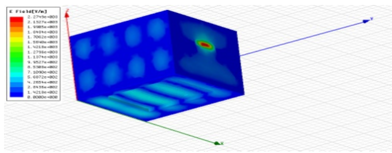
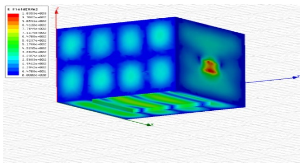
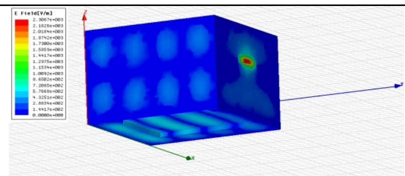
RESULTS AND DISSCUSIONS

To analyze the electric field inside the microwave system was introduced in this chestnut flour which has undergone drying, processing time is five minutes. Below are being presented the obtained results after simulating the heating process of the wet chestnut flour in the microwave field.

In the table we present the results of numerical simulation of the microwave heating process of chestnut flour where in guide was introduced several radiating slots and the results of numerical simulation where in guide has not been introduced several radiating slots. According to material taken from literature values of relative permittivity and loss factor for chestnut flour at a temperature of 20^0 C are $\varepsilon' = 12{,}4$ and $tg\delta = 2{,}60$. (Wenchuan Guo, Xiaoling Wua, Xinhua Zhu, Shaojin Wanga, 2011).

Table 1

The electric field distribution

	The electric field distribution with several radiating slots introduced in the guide	The electric field distribution with no radiating slots introduced the in guide
20^0 $\varepsilon' = 12{,}4$ $tg\delta = 2{,}60$		
40^0 $\varepsilon' = 14{,}3$ $tg\delta = 2{,}00$		
60^0 $\varepsilon' = 18{,}8$ $tg\delta = 1{,}4$		

CONCLUSIONS

The new technology with microwaves that is being proposed in this experiment opens new research areas in creating new composite materials, used in high class domains of the economy, for which the conventional forms of energy are proved to be hard to use. The problems that appear during practical realization of the microwave applicators are being related with choosing the shape and sizes of the cavity, so that the heat is being made uniform, rapid, and efficient and it doesn't destroy the quality of the dielectric material heated or dried. For these reasons, sometimes, in the cavity are being introduced auxiliary devices capable to perturb the field, and when it is possible, the body that is being exposed to heat to move.

Analyzing the results it is desired the numeric a homogeneity electric field so that the heating to be kept as firm and the efficient. It is noted that chestnut flour processing homogeneous microwave field only in the without radiating slots is not fully satisfied is why we tried placing the waveguide slots radiating to find new solutions to uniform electric field. In the process of promotion the electro-technologies based on microwave energy, an important step represents the creation of some experimental models, lab, that would permit a real analyze of the phenomenon in any moment and any circumstances of the heating process in the microwave field and once with this, the determination of some specific parameters of the problem.

REFERENCES

1. Brian Q. Phillippy, Mengshi Lin, Barbara Rasco, " Analysis of phytate in raw and cooked potatoes", Journal of Food Composition and Analysis 17, 217–226, 2004;
2. Das S., A K Mukhopadhyay, S Datta, D Basu, "Prospects of microwave processing: An overview", Bull. Mater. Sci., Indian Academy of Sciences , Vol. 32, No. 1, February 2009;
3. Friedman, M., "Chemistry, biochemistry, and safety of acrylamide. A review",. Journal of Agricultural and Food Chemistry, 51, 4504–4526, 2003;
4. Hathazi F.I., Maghiar T., 2003 Theoretical aspects regarding mono-mode applicators utilization (TE10) in fluidization treatments of the epoxy resins inside built-in mica, 7th International Conference on Engineering of Modern Electric System, Session Electrical Engineering, May 29 – 31, 2003, Oradea, pp.120 – 125.
5. Helmar Schubert, Marc Regier, "The Microwave Processing of Foods", Woodhead Publishing Limited, Cambridge England, 2005;
6. Jaspreet Singh, Lovedeep Kaur, "Advances in Potato Chemistry and Technology", Elsevier, 2009;
7. Juming Tang, Feng Hao, Ming Lau, " Microwave Heating in Food Processing", Advances in Bioprocessing Engineering, World Scientific Publishing Co, pp.1-44, 2012;
8. M.A.M. Khraisheh, W.A.M. McMinn, T.R.A. Magee, "Quality and structural changes in starchy foods during microwave and convective drying", Elsevier, Food Research International 37 (2004);
9. Maghiar T., Soproni D., 2003, Tehnica încălzirii cu miocrounde – Editura Universității din Oradea
10. Metaxas A.C., J.D. Driscoll, 1974, Comparison of the Dielectric Properties of Paper and Board at Microwave and Radio Frequencies, Journal of Microwave Power;
11. Metaxas, A.C., Meredith, R.J., Industrial Microwave Heating, Peter Peregrinus LTD (IEE), 1983, London, (UK),.
12. Molnar, C. O., Soproni, D.V., Arion, M.N, Bandici, L., 2008, "Temperature Distribution in the Humid Powder Beds Dried in Microwave Field and Warm Air", Annals of the Oradea University, Fascicle of Electrical Engineering, pp. 99-102,.
13. Nelson, S. O. 1995. Assessment of RF and microwave electric energy for stored-grain insect control, 1995, Annual Internat. ASAE Meeting, June 18-23, , Chicago, Illinois. Amer. Soc. Agric. Engin., St. Joseph, Michigan. 16 pp.;
14. Ryynänen, S. 1995. The electromagnetic properties of food materials: A review of the basic principles. J. Food Eng. 26(4): 409-429.
15. Shyam S. Sablani, Arun S. Mujumdar, " Drying of Potato, Sweet Potato, and Other Roots", Taylor & Francis Group, 2006;
16. Soproni V.D, F.I. Hathazi, M.N. Arion, C.O. Molnar, 2009, "Aspects Regarding the Adapting and Optimization of Mixed Drying Systems Microwave-Hot Air for the Processing of Agricultural Seeds", PIERS Proceedings, Beijing, China, pp. 210-213;
17. Szabo G., Rajko R., Hodur C.,"Combined Energy Transfer (microwave-convective) by drying agriculture materials", Hungarian Agricullture Engineering, Vol.11, pp.23-25, 1998;
18. Wang S., M. Monzon, Y. Gazit, J. Tang, E. J. Mitcham, J. W. Armstrong," Temperature - Dependent Dielectric Properties of selected subtropical and Tropical Fruits and Associated Insect Pests" American Society of Agricultural Engineers Vol. 48(5): 1873−1881, 2005.
19. Wen-Chuan Guo, Stuart O. Nelson, Samir Trabelsi, Stanley J. Kays, "10–1800-MHz dielectric properties of fresh apples during storage", 2007;
20. Wenchuan Guo, Xiaoling Wua, Xinhua Zhu a, Shaojin Wanga, - Temperature-dependent dielectric properties of chestnut and chestnut weevil from 10 to 4500 MHz - biosystems engineering 110, 340 e 347 2011.