EXPERIMENTAL DETERMINATION OF THE DIELECTRIC PROPERTIES OF FRUITS (USING ULTRA-HIGH FREQUENCY (UHF) ELECTROMAGNETIC FIELD (EMM) ENERGY)

A.O.Uzaydullaev (PhD)
Gulistan State University

https://doi.org/10.5281/zenodo.7566270

Abstract. *The article presents the researches conducted through the dielectric properties of pomegranate. In heating with the help of ultra-high frequency electromagnetic field energy, the design of the chamber, the determination of their moving speed, as well as the results of the experiment and the results related to this research are given. Dielectric properties of products are important when calculating food processing modes.*

Keywords: *ultra high frequency, electromagnetic field, frequency range, temperature, resonant, wave, transmitter, conduction complex, currents, generator, valve, detector.*

Dielectric properties of products are important in dielectric heating, that is, in heating with the help of ultra-high-frequency (UHF) electromagnetic field (EMF) energy, in the design of the working chamber of devices, in determining their moving speed, as well as in calculating food processing modes.

Such information can be determined experimentally in the extremely high frequency range by various methods. The choice of these methods depends on the composition of the product, temperature and in which frequency range to measure.

Due to the variety of tasks, there is no universal measurement method of dielectric properties. Dielectric properties measurement methods differ in the following main indicators. These include frequency range, dielectric constant measurement limit, and absorption tangent angle; the accuracy of measuring these quantities; amount of sample material used; temperature range of the experiment; including solid, liquid, and gas state of the products, the measurement suitability of the method, the complexity of sample preparation, the cost of the equipment, the convenience of the experiment, and the complexity of the calculation.

Commonly accepted methods in the field of UHF include: resonant, wave, transmitter, free wave, and slow wave methods.

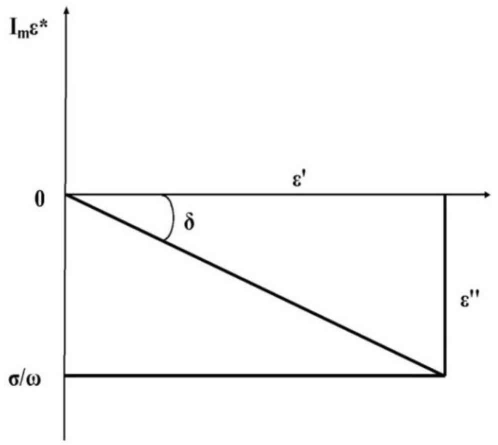
Modernization of waveguide methods is common nowadays. Such diversity is due to the cross-section of its various waveguides: distinguished by the fact that it is filled with a rectangular or completely or partially checked product. A particular modification of this method depends on the nature of propagation of electromagnetic waves in the waveguide, as well as on the principle of the search for waves reflected from the dielectric or passed through the dielectric, and on the other hand, where the waveguide line and the sample are placed: on a line connected by experiment, (“experiment”) and released (“hollow rod” method) or their combination with approved loading or absolute absorption; with the product under investigation, by varying the thickness of the layer forming an infinite layer in the waveguide, such as by partially filling the cross section of the waveguide.

In the process of processing food products with the help of UHF EMF energy, their dielectric properties must be known. The conductivity of the product is characterized by the complex ε^*dielectric conductivity, and the dielectric property of the dielectric (products) is determined by its current conductivity.

In the complex matrix in the dielectric, the complex dielectric property ε^* is characterized by the real vector ε' and is characterized by the polarization processes, which are characterized by the "mixed" currents and its "minimum" part, the conduction current. (Figure-1)

Figure-1.

Complex dielectric constant



In this, the minimum heating of the dielectric under the influence of the electric part of the EMF is understood and is defined by $\varepsilon'' = \frac{\sigma}{\vartheta}$. They can also be described by a tangent angle:

$$tg\delta = \frac{\varepsilon''}{\varepsilon'} = \frac{\sigma}{\vartheta} \cdot \frac{1}{\varepsilon'}. \quad (1)$$

The larger the angle $tg\delta$, the more energy is spent on heating the dielectric.

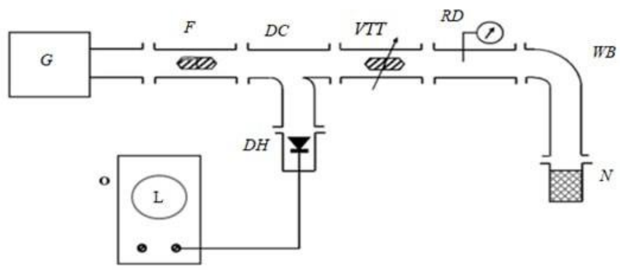
The complex dielectric permittivity and its components ε' and ε'' depend to a great extent on the frequency of the affected field, temperature and other physical and mechanical properties.

We measured the dielectric conductivity of pomegranate fruit by the method of "conducting an experiment" in the device whose block diagram is shown in Fig.2.

Figure-2 shows the block diagram of the device for measuring the dielectric conductivity of food products.

Figure-2.

Block diagram of the installation for measuring the dielectric conductivity of food products.



G - is a microwave measuring generator
F - ferrite gate (separation)
DC - directional connector
DH - detector head

O - is an oscilloscope

N - is the cross-section of the waveguide short-circuited with the studied dielectric (load).

VTT - is a variable attenuator

ML - measurement line

RD - recording device (microammeter M-95 or measuring amplifier U2-4)

WB - wave bending.

Dielectric conductivity measuring device is composed as follows. The device has a generator G, which is a source of measurement of the signal of UHF. For the stable operation of the generator, a ferrite valve is installed to eliminate the electromagnetic waves from the load. The directional valve serves to return part of the NO UHF energy. The energy from it is sent to the oscilloscope O through the detector head DC. The oscilloscope serves as an indicator of the uniform level of power supplied from the generator. A controlled attenuator VTT provides the ability to vary the power regardless of the generator power. The measuring line ML is considered the main element of the device and is used to measure the wavelength, the standing wave coefficient P, and the minimum electric field D_R in the waveguide.

The recording equipment RD captures the application of the standing wave field and the propagation of the field to obtain quantitative information.

Bending WB of the waveguide is used in the search for liquid dielectrics to obtain the waveguide N vertical standing wave experiment.

Based on the experimental research methodology, we tested the dielectric property (conductivity) of pomegranate fruit using the following experimental methodology:

This includes the following sequence.

1. After turning on the external shunt and preparing the device (Fig.2), the GZ-10A generator is added to the experimental stand;

2. We connect the experimental waveguide of the waveguide to the bend of the waveguide, only it should not be filled with the product (dielectric);

3. By changing the position of the wave line detector after heating the generator, the position of the standing wave minimum relative to the free base plane is found;

4. By measuring the minimum distance between the standing waves, the wavelength λ_e of the waveguide is calculated. The wavelength is twice the measured distance.

5. The section of the experimental waveguide was filled with the product under investigation. When filling, it is necessary to pay attention to the tight closing of the dielectric (product) to the edges of the waveguide.

6. The position of the D-standing wave minimum relative to the base plane is measured.

7. Measurement of standing wave coefficient:

$$D_{\prime} = \left(\frac{I_{max}}{I_{min}}\right)^{\frac{1}{2}} \qquad (2)$$

In this: I_{max}-microammeter reading at maximum standing wave;

I_{min}-minimum standing wave microammeter reading.

8. A similar measurement is made at a different dielectric thickness at l_2 and at D_2

9. $\beta = \frac{2\pi}{\lambda_b}$ is considered. (3)

10. For the measured D:

$$\varphi_{\prime} = 2\beta(D_{\prime} - D_R - \ell_{\prime}) \text{ and } |\Gamma_{\prime}| = \frac{P_2 - 1}{P_1 - 1} \qquad (4)$$

is considered.

11. A complex number is determined:

$$C_1 < -\psi_1 = \frac{1}{j\rho\ell}\left(\frac{1-|\Gamma_2|\cdot\ell^{j\cdot\varphi_3}}{1+|\Gamma_{\prime}|\cdot\ell^{j\cdot\varphi_2}}\right) \tag{5}$$

12. $C_1 < -\psi_1 = \frac{th(T_{\prime} < \tau_{\prime})}{T_{\prime} < \tau_{\prime}}$ equation is solved with respect to T_I and τ_I;

13. We calculate the corresponding complex numbers:

$$Y_{\prime} = \left(\frac{T}{\beta\ell_{\prime}}\right)^2 [\cos 2(\tau_{\prime} - 90^0) + j\sin 2(\tau_{\prime} - 90^0)] \tag{6}$$

14. We calculate the same for dielectric thickness l_2:

$$\varphi_2 = 2\beta(D_2 - \ell_2) \text{ and } |\Gamma_{\prime}| = \frac{P_1 1}{P_2} \tag{7}$$

15. Determination of the complex number;

$$C_2 < -\psi_2 = \frac{1}{j\rho\ell}\left(\frac{1-|\Gamma_2|\cdot\ell^{j\cdot\varphi_2}}{1+|\Gamma_2|\cdot\ell^{j\cdot\varphi_2}}\right) \tag{8}$$

and the following equation is solved;

$$C_2 < -\varphi_2 = \frac{th(T_2 < \tau_2)}{T_2 < \tau_2} \tag{9}$$

16. We calculate the corresponding complex number:

$$Y_2 = \left(\frac{T}{\beta\ell_2}\right)^2 [\cos 2(\tau_2 - 90^0) + j\sin 2(\tau_2 - 90^0)] \tag{10}$$

17. ε', ε'' and $tg\delta$ are calculated by choosing the appropriate Y quantity:

$$Y = g + j\beta \tag{11}$$

$$\varepsilon' = \frac{g + \left(\frac{\lambda\beta}{2d}\right)^2}{1 + \left(\frac{\lambda\beta}{2d}\right)^2} \tag{12}$$

$$\varepsilon'' = \frac{B}{1 + \left(\frac{\lambda\beta}{2d}\right)^2} \tag{13}$$

$$tg\delta = \frac{\varepsilon''}{\varepsilon'} \tag{14}$$

where: δ - is the length of the wide part of the waveguide.

Experimental study of the dielectric properties (conductivity) of pomegranate juice, the results obtained and calculated according to the above methodology were included in the table:

Table

Dielectric conductivity of pomegranate fruit

№	Pomegranate varieties	Amount of juice, %	Dielectric conductivity $f = 2300\ мГц$ $t = 20^0C$		
			ε'	ε''	$tg\delta$
1.	Kazakh pomegranate	40-45	60,2	16,1	0,27
2	Red pomegranate	45-50	61,3	17,2	0,28
3	Spicy pomegranate	25-30	56,7	15,4	0,27
4	Black pomegranate	30-35	59,6	15,8	0,26
5	The real pomegranate	25-30	57,1	14,9	0,26
6	Pink goulash (white pod sweet)	20-25	53,8	14,3	0,28

The information given in the table shows that juices obtained from local varieties of pomegranates grown in Mirzaabad district of Sirdarya region were used.

In conclusion, it can be said that the dielectric conductivity of pomegranate juice depends on the pomegranate varieties. Their amount mainly depends on the amount of juice in the pomegranate - the amount of liquid. Similarly, they depend on the frequency and temperature of the UHF EMF.

REFERENCES

1. N.R. Barakaev, J.M. Kurbanov, A.O. Uzaydullaev, A.X. Gafforov "Qualitative purification of pomegranate juice using electro flotation" IOP Conference Series: Earth and Environmental Science, 2021/9/1, T-848, 012024 p.
2. Kurbanov Jamshid, Barakaev Nusratilla, Uzaydullaev Akmal "Qualitative purification of pomegranate juice using electroflotation" Universum: technical science, 2021 № 10-5 (91) 47-51 pp.
3. Barakaev N.R., Kurbanov J.M., Uzaydullaev A.O. Pasteurization pomegranate juice by extremely high-frequency electromagnetic field energy // «Technical science and innovation», Ташкент: 2020. №4, 246-252 pp.
4. Kurbanov J.M., Uzaydullaev A.O. Experimental determination of the dielectric properties of pomegranate fruit // A collection of articles of the 29th scientific and technical conference of young scientists, graduate students and undergraduate students "Promising chemists-2020", Tashkent, 2020. -P.297-298.
5. Uzaydullaev A.O. Creation of a technology for extracting juice concentrate from local pomegranate varieties // Dissertation. Abstract Gulistan - 2022.
6. Eshmatov F.Kh. Development of technology for adjusting the acidity of pomegranate juice and reducing the turbidity index // Dissertation. Abstract Tashkent-2017.