Journal of Applied Sciences

ISSN 1812-5654

Journal of Applied Sciences 7 (7): 1009-1012, 2007
ISSN 1812-5654

Study on Complex Permittivity of Tropical Thai Fruits

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Abstract: In this study, the complex permittivities including dielectric constants, dielectric loss factors and loss tangents of fruits - apple, orange, lemon and pineapple were studied. From the tests, we have found that the complex permittivities depend upon the operating frequency of electromagnetic wave and the date.

Key words: Complex permittivity, fruits, network analyzer

INTRODUCTION

Thailand is one of the agricultural exporter countries, for example; fruits, vegetables, fish, rubber etc. Fruits such as orange, pineapple etc are the important exported fruits of Thailand. A number of the nondestructive and destructive methods was been used to inspection. For instance, mango and durian inspection was studied by Krairiksh *et al*. (2004) using inverse scattering technique and Kongrattanapraset *et al*. (2001) using force vibration and ultrasonic, respectively. In addition, Nelson and Bartaly (2002) measured the permittivity of a homogenized macaroni, cheese, wheat apple juice.

In this research, we study the behavior of dielectric constant, dielectric loss factor and loss tangent of four juices - apple, orange, lemon and pineapple which depend upon frequency and age. Firstly, the parameters of material are reviewed and followed by measurement. Results are shown in topic 3 and finally concluded.

DIELECTRIC PARAMETERS

In this topic, we briefly review the permittivity of materials. This parameter indicates the electromagnetic energy stored in a material.

Generally, the permittivity is a complex number whose real and imaginary parts depend upon frequency as equation Balanis (1989):

$$\varepsilon(f) = \varepsilon'(f) - j\varepsilon''(f) \tag{1}$$

where $\varepsilon'(f)$ and $\varepsilon''(f)$ are the real and imaginary parts of complex permittivity, respectively.

Divided Eq. 1 by permittivity of free space ε_0 , it sis known as the relative complex permittivity, $\varepsilon_r(f)$,:

$$\varepsilon_r(f) = \acute{\varepsilon}_r(f) - j\varepsilon''(f) \tag{2}$$

where the real part, $\acute{\varepsilon}_r(f)$, is the dielectric constant and the imaginary part, $\varepsilon_r''(f)$, is the dielectric loss factor.

The $\varepsilon_r''(f)$ indicates the loss and conductivity of material as below equation:

$$\varepsilon_r''(f) = \frac{\sigma}{2\pi f\varepsilon_0} \tag{3}$$

where σ is the conductivity and f is the operating frequency of electromagnetic wave.

The definition of loss tangent, which is another important parameter of dielectric, is the ratio of imaginary part to real part of complex permittivity given by;

$$\tan\delta = \frac{\varepsilon''}{\varepsilon'} \tag{4}$$

where δ is the loss tangent of material.

MEASUREMENT

The electrical equipments to measure the complex permittivities of fruits are Network Analyzer E5061A, coaxial cable RG-58A/U and dielectric probe. The regular calibration procedure is performed under open-circuit, short-circuit and distilled water at temperature of 25°C references. Dielectric constants and dielectric loss factors are calculated by Agilent Technologies 85070 Dielectric Probe Kit Software version E1.00. In this paper, four samples of fruits; apple, orange, lemon and pineapple, are studied on a frequency range from 20 kHz to 1.5 GHz.

RESULTS

The variation of permittivity properties of four fruits on the first day was performed at 20 MHz, 790 MHz and 1.5 GHz as shown in Table 1 and Fig. 1.

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The trend of loss tangent is likewise and the loss tangent on date 2 is the lowest. At the low frequency, the loss tangents are high and then drastically decrease on high frequency range. The dielectric constant and dielectric loss factor parameters on the first date are shown in Fig. 2.

From Fig. 2, At the low frequency, the dielectric constant, dielectric loss factor and loss tangent of lemon and apple are the highest and lowest, respectively. After that all of parameters decrease as the frequency increases.

Loss tangent of apple and orange at 20 MHz, 286, 790 and 1.5 GHz, shown in Fig. 3, is the same pattern. The oscillation of loss tangent occurs at 20 MHz and then it is stable at 286, 790 MHz and 1.5 GHz.

Table 1: Permittivities of four juices at various frequency

Freq.	20 MHz		790 MHz		1.5 GHz	
Fruits	ε'_r	ε''_r	ε'_r	ε''_r	ε'_r	ε''_r
Apple	115.8	174.3	76.8	9.8	74.7	11.7
Orange	134.3	253.2	74.4	11.8	72.4	11.7
Lemon	147.1	324.8	76.0	12.5	74.7	11.3
Pineapple	127.0	225.2	76.3	10.8	74.4	11.3

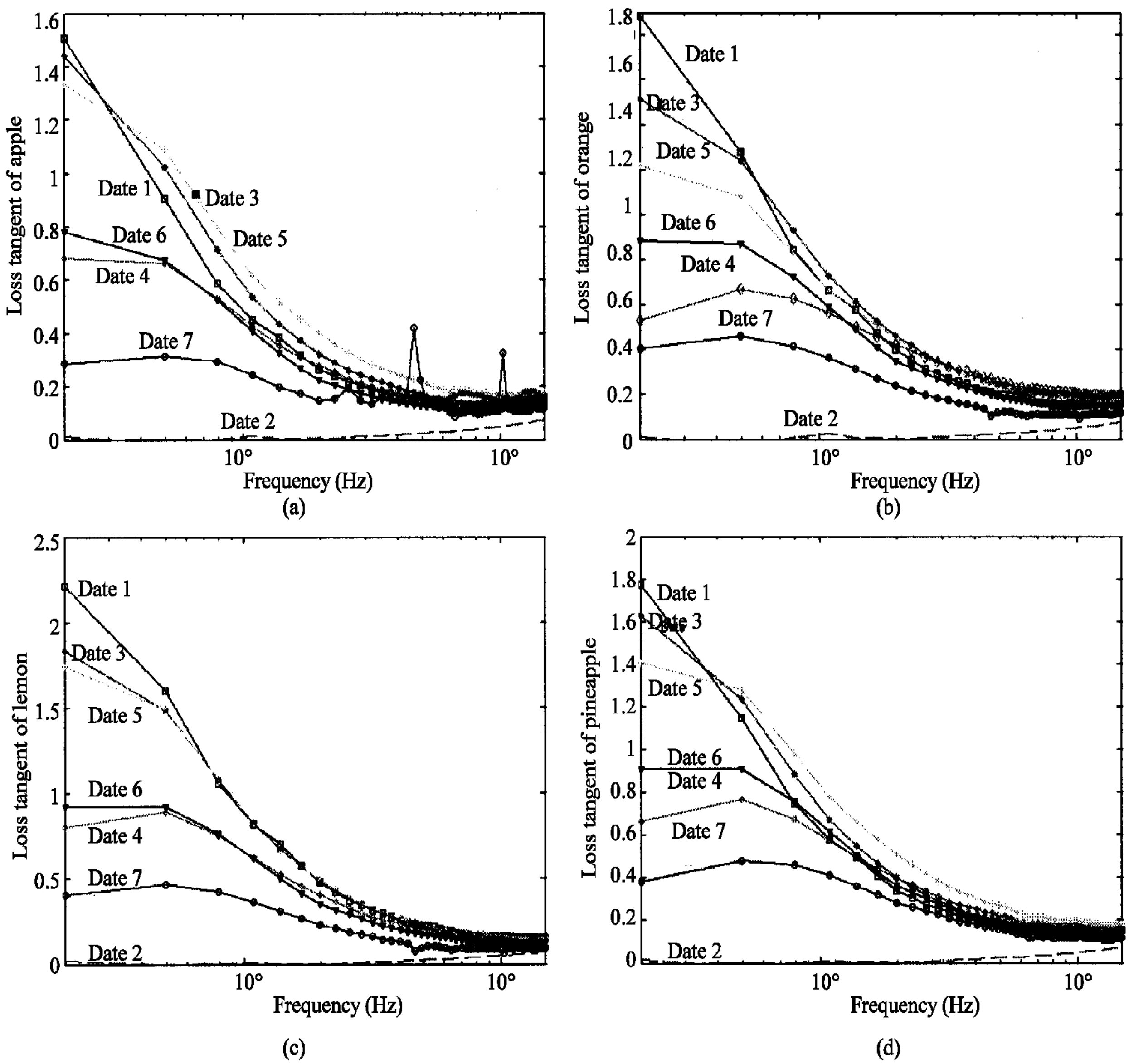

Fig. 1: Loss tangent of fruits vs frequency for (a) apple (b) orange (c) lemon and (d) pineapple

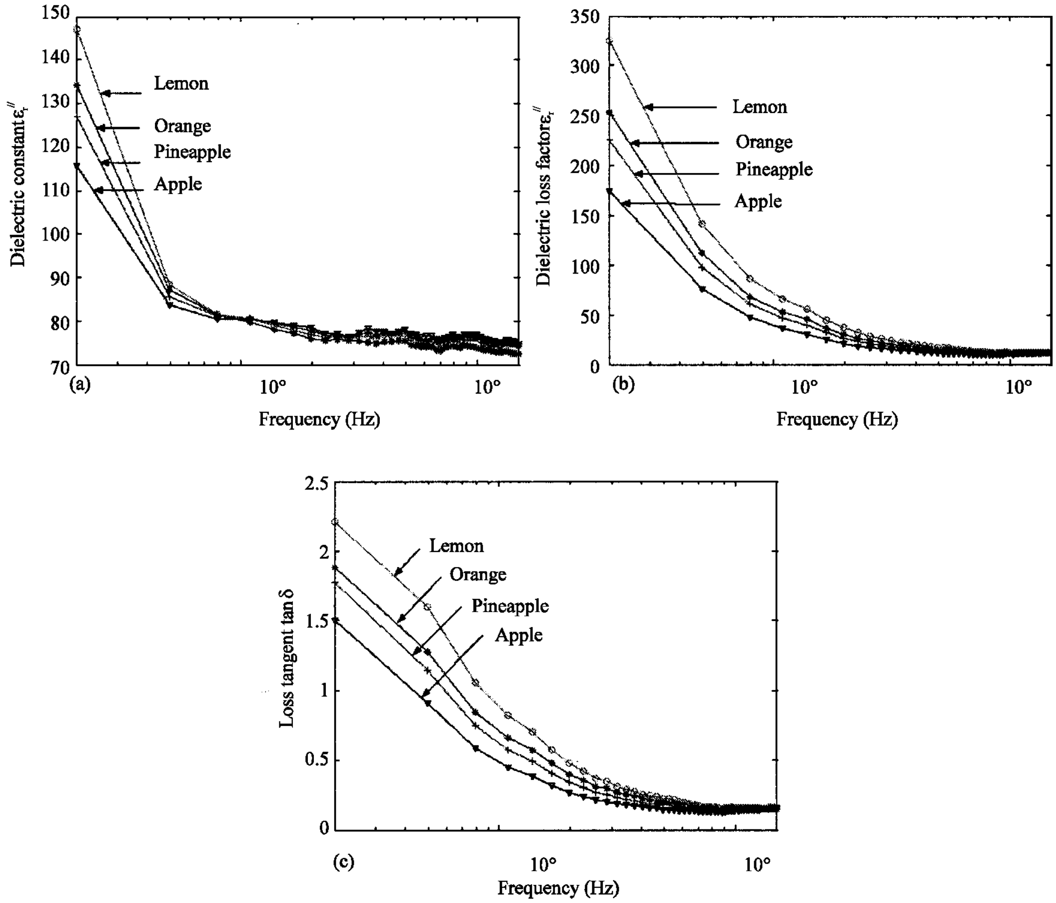

Fig. 2: Dielectric parameters of sample fruits vs frequency on the first date in terms of (a) dielectric constant (b) dielectric loss factor and (c) loss tangent

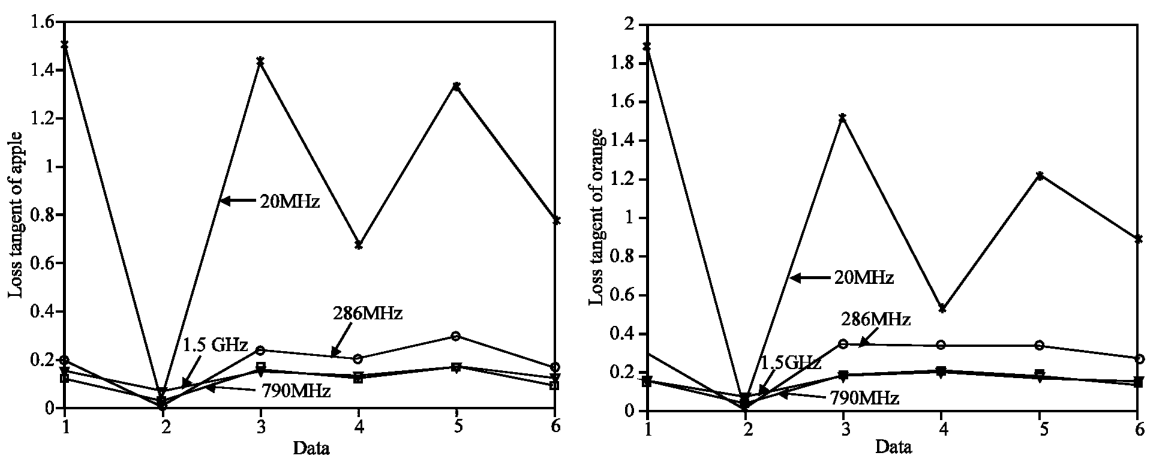

Fig. 3: Loss tangent of sample fruits vs date for (a) apple and (b) orange

CONCLUSIONS

It is seen from this study that loss tangent, dielectric constant and dielectric loss factor are obviously shown at low frequency. The oscillation of these parameters on each date is thought to be due to the uncompleted fermentation. However, these parameters tend to decrease as the age increases.

ACKNOWLEDGMENTS

The authors wish to thanks the EMC laboratory at the department of Electrical Engineering, Khon Kaen University, Khon Kaen, Thailand who has supported all the test equipments.

REFERENCES

Balanis, C.A., 1989. Advanced Engineering Electromagnetics. John Wiley and Sons Inc., USA.

Kongrattanapraset, W., S. Arunrungrusmi, B. Pung-siri, K. Chamnongthai and M. Okuda, 2001. Nondestructive maturity determination of durian by force vibration and ultrasonic. Int. J. Uncertainty, Fuzziness and Knowledge-Base Sys., 9: 703-719.

Krairiksh, M., A. Mearnchu and C. Phongcharoenpanich, 2004. Nondestructive measurement for mango inspection. Proc. Int. Sympo. Commun. Information Technol., 26-29 October 2004, Sapporo, Japan.

Nelson, S.O. and P.G. Bartley, Jr., 2002. Measuring frequency- and temperature - dependent permittivities of Food Materials. IEEE Trans. Instrumentation and Measurement, 51: 589-592.