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Determination of Reflection Coefficient, S_{11} by Varying the Monopole Ground based on CST Simulation

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Abstract: The increase in production of oranges has led to numerous studies; some investigate the nutrients inside the fruit while some investigate the benefits of orange. Nevertheless the purpose of prior studies is similar which is to determine the quality attributes of the fruit. The process can be done destructively and non-destructively. This study focuses on microwave sensing as a method in determine the soluble solid content. It is first done by simulation of the modelling which consists of a nylon bowl, Teflon, connector and antenna in which the number of monopole ground is the manipulative variable. The results of this simulation emphasize on the reflection coefficient, S_{11}. The most number of monopole has higher S_{11} which has higher reflected power.

Key words: Reflection coefficient, monopole sntenna, citrus orange, CST Software, determination

INTRODUCTION

Citrus fruits are very popular among Malaysians whether they are imported or grown locally. In Malaysia the production of citrus is quite high (Lim *et al*., 1990). There are various type of citrus but the two most sought after in Malaysia are citrus chinensis and citrus suhuiensis. These two are favoured because of their taste and nutritional values (Table 1).

Over the years, extensive studies have been done on determining the nutrients and the quality attributes of oranges internally and externally. Popular applications for sensing permittivity can be found in the wide field of process control such as food or drug production (Vehring *et al*., 2015).

Microwave Non-Destructive Testing (MNDT) of materials is an important experiment which involve development of sensor and probes, methods and calibration techniques for detection of flaws, cracks, defects, voids and moisture content, etc. by means of microwaves (Al-Mattarneh *et al*., 2001). In microwave, there are many sensors to be used such as monopole, dipole and patch antennas. These methods can be used in different manners in obtaining the soluble solid content of citrus. In this study, the modelling is done by using CST Software. The purpose of this study is to obtain reflection coefficient, S_{11} by manipulating the number of monopole ground.

Table 1: Nutrient composition of sweet orange (Etebu and Nwauzoma, 2014)

Compositions	Amounts
Energy	197 kJ (47 kcal)
Sugars	9.35 (g)
Dietary fibre	2.4 (g)
Fat	0.12 (g)
Protein	0.94 (g)
Water	86.75 (g)
Vitamin A equiv.	11 ug (1%)
Thiamine (Vit. B1)	0.087 mg (8%)
Riboflavin (Vit. B2)	0.04 mg (3%)
Niacin (Vit. B3)	0.282 mg (2%)
Panthotenic acid (B5)	0.25 mg (5%)
Vitamin B6	0.06 mg (5%)
Folate (Vit. B9)	30 ug (8%)
Chloine	8.4 mg (2%)
Vitamin C	53.2 mg (64%)
Vitamin E	0.18 mg (1%)
Calcium	40 mg (4%)
Iron	0.1 mg (1%)
Magnesium	10 mg (3%)
Manganese	0.025 mg (1%)
Phosphorus	14 mg (2%)
Potassium	181 mg (4%)
Zinc	0.07 mg (1%)

MATERIALS AND METHODS

Fundamental of permittivity and reflection coefficient: The most valuable parameter in food engineering and technology is the dielectric properties of food and biological products (Sosa-Morales *et al*., 2010; Icier and Baysal, 2004). The dielectric properties of most materials vary with several factors. In agricultural products, the amount of water in the materials is generally a dominant factor (Rutpralom *et al*., 2002). The dielectric properties also depend on frequency of applied electric field,

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temperature, density, structure and chemical composition of materials measurement of dielectric properties involves measurements of the complex relative permittivity and complex relative permeability of the materials (Anonymous, 2006). A complex dielectric permittivity consists of a real part and an imaginary part. The real part of the complex permittivity also known as dielectric constant is a measure of the amount of energy from an external electrical field stored in the material. The imaginary part is zero for lossless materials and is also known as loss factor. It is a measure of the amount of energy loss from the material due to an external electric field. It can be written as:

$$\varepsilon = \varepsilon' - j\varepsilon''$$

Reflection coefficient can be expressed as:

$$S_{11} = R(1-T)^2 / 1 - T^2R^2$$

R can be rewrite as: lastly, the relationship of permittivity and reflection coefficient can be simplified into:

$$\varepsilon = \frac{k}{k\upsilon}\left(\frac{1-R}{1+R}\right)$$

One way to prove this is by experimenting it virtually. Which can be done by doing simulation via. CST Software.

CST simulation: CST studio suite has grown into a comprehensive simulation tool, capable of dealing not only with electromagnetic simulations but also with related tasks such as temperature, mechanical stress or circuit simulation. Hence, it is reliable to use this software for this particular purpose (Fig. 1-4).

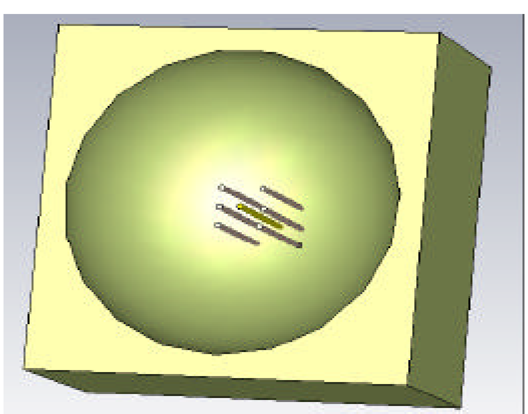

Fig. 1: CST image of 6 poles with bowl

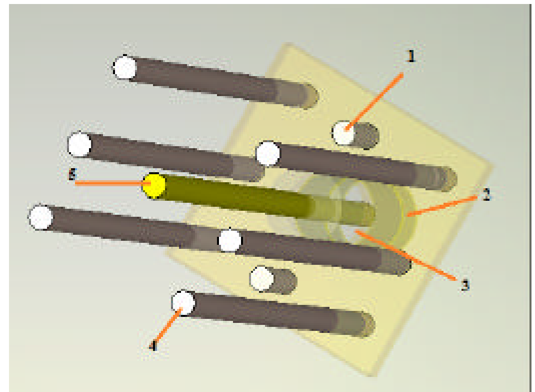

Fig. 2: CST image of 6 poles

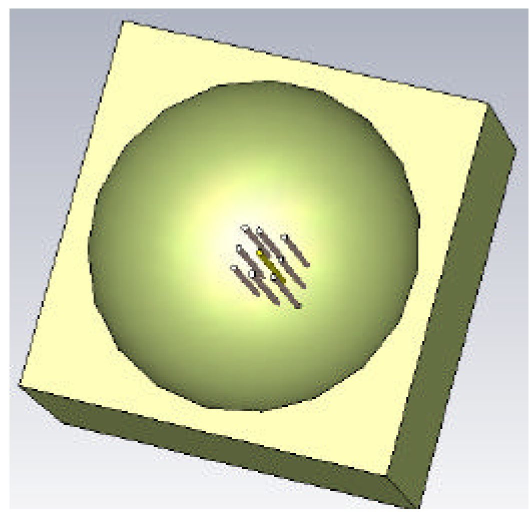

Fig. 3: CST image of 8 poles with bowl

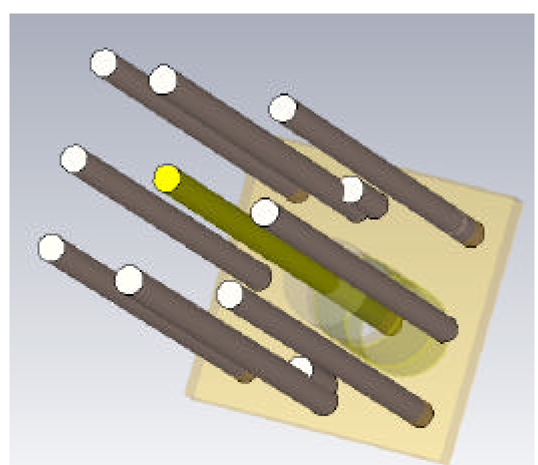

Fig. 4: CST image of 8 poles

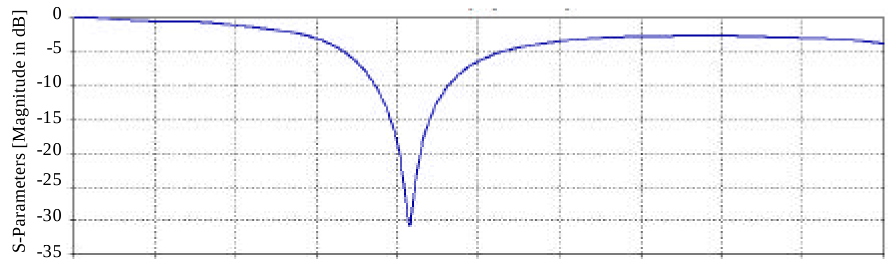

Fig. 5: The graph of S_{11} results for 6 monopole ground

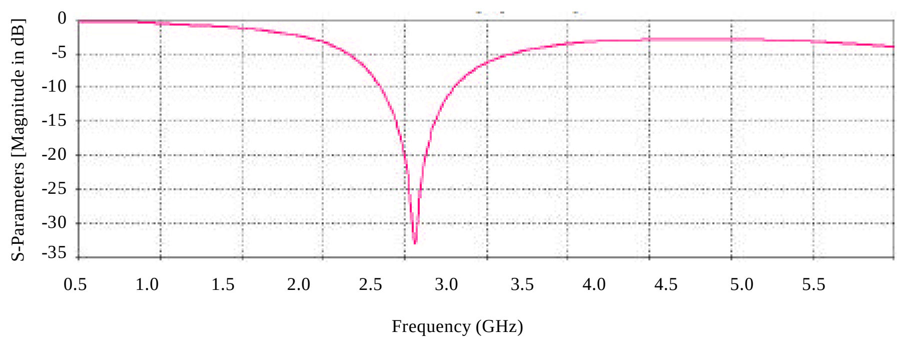

Fig. 6: The graph of S_{11} results for 8 monopole ground

The monopole sensor is designed by using CST Software specifically to measure the reflection coefficient, S_{11} of citrus fruit. First, the modelling is developed by designing a nylon bowl that can uphold the fruit sample on top of the tip of monopole antenna. The reason nylon is being used because the holder should have relative permittivity nearer to air permittivity to minimize the EM wave reflection (Rosman *et al*., 2014). According to Fig. 2, the details of this modelling are as follows: (Fig. 3-6):

- Screw
- Connector
- Teflon
- Monopole ground
- Middle antenna

RESULTS AND DISCUSSION

Figure 5 and 6 show the value of S_{11} for both 6 and 8 monopole ground. The results are -30.03 and-32.02 dB, respectively. This shows that by having more monopole ground in the modelling, more power is being reflected. Since, the simulation provide this values, the measurement is expected to be around these values. In finding out the soluble solid content of local orange, the measurement of dielectric permittivity should be taken into account.

In recent study, Rosman carefully stated the range of relative permittivity, •$_r$ for the Malaysian local oranges is around 50-75. Therefore, based on the CST simulation and also the range from similar study, the soluble solid content of local oranges can be determined.

CONCLUSION

Based on the CST simulation results, it can be concluded that the monopole sensor is reliable in sensing the reflection coefficient S_{11} and hence can be used to determine the soluble solid content of local oranges. The difference in S_{11} value between 6 and 8 monopole ground significantly shows that these manipulative variables play an important role in achieving the best results and proving the relationship of S11 and permittivity, •.

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REFERENCES

Al-Mattarneh, H.M., D.K. Ghodgaonkar and W.M.W. Majid, 2001. Microwave nondestructive testing for classification of Malaysian timber using free-space techniques. Proceedings of the 6th International Symposium on Signal Processing and its Applications, August 13-16, 2001, IEEE, Malaysia, ISBN:0-7803-6703-0, pp: 450-453.

Anonymous, 2006. Measurement of dielectric material properties: Application note. Rohde & Schwarz Systems & Communications Asia Pte Ltd, Singapore. https://www.rohde-schwarz.com/pk/home_48230.html.

Etebu, E. and A.B. Nwauzoma, 2014. A review on sweet orange (Citrus sinensis L. Osbeck): Health, diseases and management. Am. J. Res. Commun., 2: 33-70.

Icier, F. and T. Baysal, 2004. Dielectrical properties of food materials-2: Measurement techniques. Critical Rev. Food Sci. Nutr., 44: 473-478.

Lim, W.H., O.M. Shamsudin and W.W. Ko, 1990. Citrus greening disease in Malaysia: Status report. Proceedings of the 4th International Asia Pacific Conference on Citrus Rehabilitation, February 4-10, 1990, FAO, Rome, Italy, pp: 100-105.

Rosman, R., M.N. Dimon and Y.K. Yeow, 2014. CST simulation on monopole sensor for determination of Malaysian local oranges sweetness quality Non-destructively. Proceedings of the UKSim-AMSS 16th International Conference on Computer Modelling and Simulation (UKSim), March 26-28, 2014, IEEE, Shah Alam, Malaysia, ISBN:978-1-4799-4922-9, pp: 548-552.

Rutpralom, T., P. Kumhom and K. Chamnongthai, 2002. Nondestructive maturity determination of durian by using microwave moisture sensing. Proceedings of the IEEE International Conference on Industrial Technology ICIT'02, December 11-14, 2002, IEEE, Bangkok, Thailand, ISBN:0-7803-7657-9, pp: 155-158.

Sosa-Morales, M.E., L. Valerio-Junco, A. Lopez-Malo and H.S. Garcia, 2010. Dielectric properties of foods: Reported data in the 21st century and their potential applications. LWT. Food Sci. Technol., 43: 1169-1179.

Vehring, S., S. Guha, F.I. Jamal, D . Kissinger and C. Meliani, 2015. Permittivity sensor based on 60 GHz patch antenna. Proceedings of the Microwave Conference on German GeMiC, March 16-18, 2015, IEEE, Frankfurt (Oder), Germany, ISBN:978-3-9812-6686-3, pp: 311-314.