# A PRELIMENARY STUDY ON MICROWAVE CHARACTERIZATION OF MANGOES RIPENESS AT 18 TO 26GHz (K-BAND)

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# ABSTRACT

Microwave nondestructive testing of materials is an important science which involve development of sensors/probes, methods and calibration techniques for detection of flaws, cracks, defects, voids, inhomogeinities and moisture content This project presents a microwave non-destructive testing to determine the ripeness of mangoes at frequency range 18 to 26GHz (K-Band). The mangoes are selected to be measure using this technique because of its surface is quite planar.

This project presents a microwave free space technique for the measurement the mangoes ripeness at frequency range 18 to 26 GHz (K-Band). The component of this free space measurement system (FSMM) consists of spot focusing Gaussian Optics Lens (GOA) antennas, the Vector Network Analyzer and the computer. The thru, reflect and line (TRL) calibration technique were used to eliminate the effect of undesirable multiple reflection. The results are compared between measurement and data and presented in the frequency range of 18 to 26GHz.

The samples are sandwiched between two Perspex plates (one plate is fixed and the other is moveable) for matching to free space. Because of the far field focusing ability of horn lens antennas free space measurement can be made at microwave frequency in a relatively compact and simple measurement set up.

The dielectric constant for ripe and for unripe mangoes samples is in between 26.1 to 29.5. The loss tangent (tan δ) is average 1.14 to 1.18 for both ripe and unripe mangoes samples. The slight differences could be due to errors in the magnitude and phase of S11 and S21, surface of mangoes and the air-gap effect of the sample assembly. Loss factor, loss tangent, and conductivity of samples were obtained by using formula. These data are presented in tabular form as shown in the appendix and reported in the range of frequency 18 to 26 GHz.

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# CHAPTER 1

# INTRODUCTION

Microwave techniques have been used in a large number of applications that can be classified as nondestructive testing applications. Microwave Nondestructive Testing (MNDT) techniques have advantages over other NDT methods regarding low cost, good penetration in nonmetallic materials, good resolution and contactless feature of the microwave sensor (antenna) [1]. For MNDT techniques, the measured parameters are reflection coefficients, transmission coefficients, dielectric constants, loss factors, and complex permeabilities as a function of microwave frequency and temperature [2].

These measured parameters can be related to material parameters of interest by suitable modeling and calibration. We have employed a free-space microwave measurement (FSMM) system which can measure electromagnetic properties (complex permittivity, complex permeability, reflection coefficients, etc.) for evaluation of this material. The main advantage of this FSMM system is that with suitable modifications, it is possible to make precise, accurate and reproducible MNDT measurements on materials under high or low temperature conditions and complex electromagnetic environmental conditions due to contactless feature of free-space measurements [4].

This measurement system consists of a pair of specifics antennas, mode transitions, coaxial cables and a vector network analyzer (VNA). The inaccuracies in free-space measurements are due to two main sources of errors. I) Diffraction effects at the edges of the material specimen. II) Multiple reflections between antennas and mode transitions via the surface of the sample [2]. The spot-focusing antennas are used for minimizing diffraction effects and free-space TRL (thru,