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# A NOVEL NON-INVASIVE MEASUREMENT OF ENDOSPERM IN TENDER COCONUT USING MICROWAVES

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***Abstract*— The system proposed to measure the quantity of endosperm (water, meat and oil) inside the coconut based on microwave technology using non-destructive and non-invasive methods. The special properties of the materials which undergo physical and chemical changes, can be identified by measuring the dielectric properties of endosperm inside coconut. Microwave sensors are used to determine the dielectric properties and their reactions. Here, in this scheme, coconut is kept inside the microwave resonator to know dielectric properties of liquid and solid endosperm. When the waves are incident on to the coconut, some amount of energy is transmitted, some reflected back towards the cavity and the remaining will be absorbed. Materials having different dielectric properties will resonate at distinct frequencies. The amount of absorption depends on material endosperm dielectric properties.**

***Keywords*—Cavity Resonator, Gunn Oscillator, Neural Networks, Microwave Receiver, Absorption Coefficient.**

## I. INTRODUCTION

The share of Indian market at global level about 33% not much research is done in this respect. Most research on coconut is done by its applications. Consequently, there is no device that would check these parameters non- destructively in the market, nor even on design tables. The quantum of meet and water would be known only after skinning the coconut and then breaking it. The quantum of oil can be known only after drying the meet (when required to) and through the process cold or hot press. Hence the unskinned or skinned coconuts cannot be graded based on any of the above quality parameters. The quality is decided intuitively by the trader while purchasing them. Commercially each of the three parameters has different marketing interests and value. In 2018, various countries together contributing 60% share in the world. The assessment of quality parameters non-destructively would help the coconut business greatly by first grading them.

## II. OBJECTIVES

The proposed device finds application in Coconut Development Boards. This device assist farmers and business people & traders in fixing the amount for a coconut based on quantity of meat, oil and water. It also helps for the nutrition factories to estimate the amount of nutrients present inside coconut. Microwave resonator technique using various RF sensors based on the frequency may also use in various industries, like food, automotive, pharmaceutical, tobacco, recycling, and chemicals, to find the quantity and to identify the moisture, foreign particles and properties of dielectric materials. A cavity resonator is capable of characterizing loss less materials with low loss tangent. This can be tough to analyze with existing measurement techniques. The proposed technique allows production agencies to perform a contactless measurement and can also use in many of the manufacturing industries to measure the water content inside the material.

## III. PROPOSED DEVICE

The principle of the proposed device is to determine the quantity of coconut endosperm like meat, oil and water using microwave technology. Gunn diode is used a microwave source for the device which generates microwave signals of range GHZ to THZ. Gunn Power supply of 9-12V is required to switch on diode. Sample of coconut is placed inside a cavity resonator; it is excited to a particular resonant frequency through probe coupling. When waves are incident towards the coconut, some portion of power is reflected, and a portion is transmitted over the surface of coconut, and the remaining portion of it is absorbed. The amount of energy, which comes under these three categories, have been well-defined in terms of their dielectric properties. The complex relative permittivity of the material, $\varepsilon^*$ is related to the dielectric constant and loss factor is given by

$$\varepsilon^* = \varepsilon' - j\varepsilon'' \qquad 1$$

When a microwave energy is excited into the cavity through the probe, the part of energy gets reflected and some energy is transmitted, this is recorded by using the UHF RF reader. The amount of absorption is calculated by using beers law. Beer's Law gives the relationship between the attenuation of signal through a substance and the properties of that substance. In view of monochromatic radiation, absorbance is defined as

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$I = I0e -A$ 2

where $I0$ is Incident intensity of radiation and I the intensity after passing through the substance
The spectral transmission T is defined by

$T = I / I0$ 3
Absorbance, A is given by
$A = \ln (1/ T)$ 4

The analysis is performed for various samples at different maturity levels. And the results are plotted based on resonator frequency and the water content. After experimenting the procedure on various samples at different maturity stages, calibrated values are listed in the table and can be trained a firmware to deliver an accurate reading of the quantity of water, oil and meat inside the coconut directly without any external input.

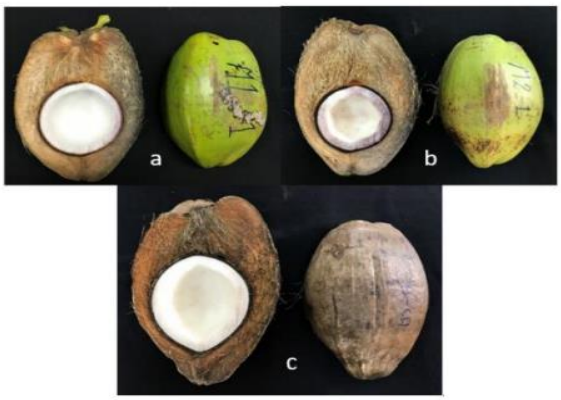


Fig 1 Maturity stages of coconut: a) young; b) early ripening; c) ripe

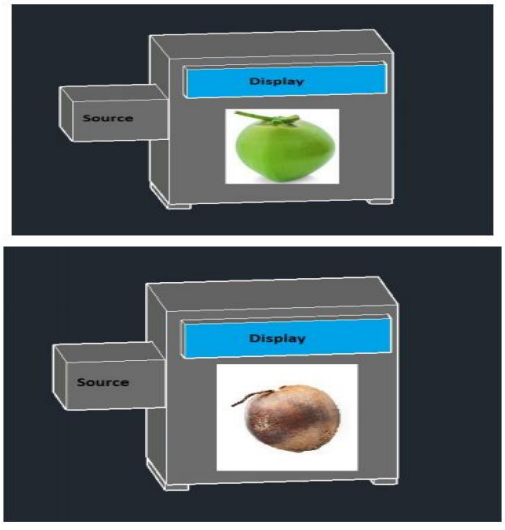


Fig 2 Prototype of Device

## IV. BLOCK DIAGRAM

The internal setup of the device is shown using block diagram

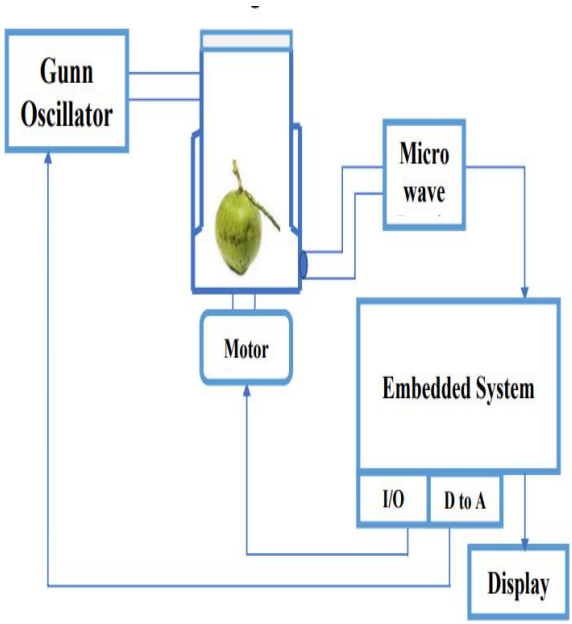


Fig 3 Internal setup of prototype

**Gunn Diode and control:** Gunn diode oscillator is used to generate microwaves, till THz frequencies. It is also known as Differential Negative Resistance device. As it transfers electrons from one valley to other valley it can also be called as transferred electron device. When a DC voltage is applied to the gunn diode the current increases with increase in voltage. When the applied voltage exceeds the threshold value according to gunn theory, the current decreases with increase in voltage there by exhibiting negative resistance region. This region is used to produce oscillations and to amplify the signals.

**Cavity Resonator with coupling probe:** The cavity resonator or microwave resonator acts as the tuned circuit at microwave frequencies similar to the LC tuned circuit at lower frequencies. Based on the required frequency the cavity is designed with adjustable knob for varying the size to measure the various parameters. The principle involved is based on the variation in resonant frequency and also depends on the absorption characteristics of a cavity, due to insertion of a sample of coconut.
The measurement is done by inserting a sample of coconut inside the cavity resonator, and the size is adjusted based on the measuring parameter. The input is applied to the resonator through the coupling probe.

**Coupling probe and Microwave Receiver**: The signals from the resonator is collected by microwave receiver through the coupling probe. The signals received by the antenna and is given to the network analyzer to display the resultant signal.

**Preamplifier with Filter**: The preamplifier amplifies the high impedance signal from microwave receiver into low output impedance signal. The filter followed by preamplifier eliminates the noise if any and outputs clean DC signal. The signal output from filter is given to PGA.

**Embedded processor**: The embedded processor processes the output digitally to derive the quantity of meat, oil and water. It has built-in facility with USB, WI-HI, Ethernet and LCD display driver. Hence it would be in a position to communicate with another device connected to USB, Ethernet. It also can display various data in digital form as well as trend graphs, etc. on LCD display. The processor carries out signal processing digitally. Due to difference in dielectric properties of meat, oil and water, we get different absorption coefficients at different frequencies. Digital signal processing is used for calibration of this multivariate curves

## V. METHODOLOGY

Different set of coconut samples are taken at different maturity stages. The dielectric constants of three materials are published as Dielectric constant of water is 80, coconut oil is 2.9 and coconut meat is 21. As there are different dielectric constants, different frequencies are employed to find the absorption coefficient of each of the three parameters. The experimentation is performed for different samples to generate the plot of frequency vs absorption that is plotted for known weights of meat, oil and water. The process of calibration is done by training of Neural networks. The prototype involves a supervised learning mechanism, in which the output given for a specific input applied. When the coconut is placed inside the cavity, then based on the training method, it looks for all the possible outcomes, for a given set of inputs using optimization techniques which results in good performance. The system then compares the resulting outputs with the given inputs.
Various learning methods are used to train the system to reduce errors and effective one is categorized and turned into hardware for fast results.

## VI. CONCLUSION AND FUTURE SCOPE

The proposed device will give the instantaneous measurement of quantity of coconut meat, oil and water and accommodates the smallest to the largest coconut and no adjustments are required for measurement of any of the parameters. It measures the water content from 0 onwards and all parameters are measured at once and no adjustments, setting required. Trending and average graphs for each of the parameter read on the large display. Finally, chargeable battery and continuous operation of 5 Hours without recharging. For various frequency bands, the dielectric materials will provide different characteristics.
The novel method to establish more resonators using different frequencies, for measuring the dielectric constant of the material. This approach will present the optimistic method for analyzing the properties of the coconut sample.

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