DEVELOPMENT OF MICROWAVE SENSING SYSTEM TO MEASURE THE SWEETNESS AND RIPENESS OF PINEAPPLE

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To my beloved parents (Mrs. Saleemah and Dr. Najm), sisters, brothers, and to all researchers.

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ABSTRACT

Sensors are the most effective tools used to integrate the industrial infrastructure that will lead in increasing the quality of the products. For industrial food companies sensors are playing a vital rule in producing healthy and natural food. This thesis represent a technique of microwave sensors. a microwave sensor to predict the moisture content of the pineapple fruit is developed. Then, the ripeness and sweetness of pineapple are estimated using conductivity and PH measurements respectively. Hence these can increase the quality of the fruit product if the system is used as a tool in the industrial fruit products. It will also extend the expiry date.

ABSTRAK

Sensor adalah alat yang paling berkesan digunakan untuk menyepadukan infrastruktur industri yang akan membawa dalam meningkatkan kualiti produk. Bagi syarikat-syarikat makanan industri sensor bermain satu peraturan penting dalam menghasilkan makanan yang sihat dan semula jadi. Tesis ini mempersemtahkan penggunaan teknik sensor gelombang mikro. Sensor gelombang mikro dibangunkan untuk meramalkan kandungan lembapan buah nanas, kemudian mengganggar kematangan dan kemanisan nanas menggunakan kekonduksian dan PH ukuran masing-masing. Ini akan meningkatkan kualiti produk buah jika sistem digunakan sebagai kaedah menghasilkan produk buah-buahan perindustrian. Ia juga melanjutkan tarikh tamat tempoh.

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LIST OF ABBREVIATIONS

MC	-	Moisture content.
PH	-	Reference of acidity scale
VHF	-	Very high frequency
VLF	-	Very low frequency
HF	-	High frequency
MF	-	Medium frequency
Rx	-	Transmitter (radiator)
EMW	-	Electromagnetic wave.
DC	-	Direct current
AC	-	Alternative current
RF	-	Radio frequency.
SL	-	Sweetness level
RL	-	Ripeness level.
TSS	-	Total soluble solids.
安川明夫	-	Name of an Author in Chinese language.

LIST OF SYMBOLS

σ	-	Conductivity (μS)
F	-	Frequency (GHz)
P_r	-	Transmitted power (mW/dBm)
m_w	-	Weight of moisture.
w_1	-	Weight after drying.
w_0	-	Weight before drying.
w_w	-	Weight of water.
ω	-	Angular frequency
εr	-	Permittivity of the material.
β	-	Phase constant.
μ	-	Permeability of the material.
$\epsilon *$	-	Complex permittivity.
$\mu *$	-	Complex permeability.

CHAPTER 1

INTRODUCTION

1.1 Background

Statistics of the pineapple products in 2008, showed that the production of the pineapple in the world is approximately 25 percentage of the total tropical fruit production. The estimated quantity of pineapple fruit product is over 82.7 million tonnes. Two types of pineapple products are widely popular fresh and juice products. 19.7 million tonnes are fresh pineapple products. Nowadays, people like to have more natural food products. This pushed companies to increase the originality and the quality of the products. In order to achieve high quality of food products; the production process should be of high complex. Fruit products are highly influenced by production process stages where sweetness, acidity taste are highly variable to the reservation environment of the cans such as temperature, time, types of bacteria being created inside the can which in turn influenced by concentration of justified PH inside the can. In order to control these parameters high accuracy sensors are required to build the pre-processing stages of sensing before the products are being processed. In this research, a microwave sensor is developed based on the reflection of the voltages being directed from the pineapple samples. Two features of the pineapple can be extracted; the first is the ripeness stage of the pineapple using PH measurements. second is the sweetness level of pineapple in terms of conductivity, linear equations for both characteristics are built in order to perform sensing operation.

1.2 Problem Statement

Canning process includes pasteurization of the fruit to be 5.0 in order to allow useful bacteria to grow for food reservation while an in-situ PH measurement does not exist, conventional PH measurement is not effective for industrial proposes (time consuming). By knowing the ripeness, an accurate PH justification is possible, hence, the can will have longer expiry date (Downing, 2013). The second problem is happening in juice product process where an amount of artificial sugar (artificial sweetening) is added. Sugar provides quick energy and a concentrated source of calories. This benefit has its side effects, however, because our body consume too many calories, regardless of the source. This contributes to obesity and sugar is a major contributor to tooth decay (Mariotti & Lucisano, 2014). Hence by knowing the sweetness level leads to ability to control the added amount of artificial sugar for more natural fruit products.

1.3 Research Aim and Objectives

The main objective of this research is to develop a microwave sensor that can predict the Moisture Content (MC) of pineapple based on the reflected voltage. This sensor helps to achieve goals of:

- Estimation of ripeness level in terms of PH by the reflected voltage from the sensor.
- Estimation of the sweetness level in terms of the reflected voltage from the sensor.

1.4 Research Scope and Limitations

To study the characteristics of any fruit or food, it should be noted that the major components of such fruit is its MC. by knowing the structure of the MC and its development in the cultivation stages of a fruit will lead to have knowledge on other fruit characteristics which are correlated to MC. Conductivity and acidity level are features used in this research in order to predict the sweetness and ripeness of the pineapple. The PH (acidity concentration) is the value used to predict ripeness level and the conductivity is used to represent the sweetness level of the tropical pineapple fruit. A “Minitab” is powerful statistical software used to analyze the data collected from the experiments and to perform linear regression to describe the correlations of the data being gained.

1.5 Research Significance

The significance of the research is as follows:

i. Statistical analysis to prove that the developed sensor has an ability of measuring the characteristics of the pineapple.
ii. Maximum drying time to obtain the moisture content of pineapple is accurately obtained by a series of experiments with blast drying mode.
iii. Wide range of frequencies and dBm power sources are tested in order to have high resolution of analysis for future researchers.
iv. Ripeness and sweetness in pineapple are accepted to be linearly related with different growing stages.
v. This is the first microwave sensor developed that can detect the characteristics of the pineapple and detect its moisture content.

1.6 Thesis Outline

This thesis contains six chapters including the present chapter which covers the background, problem background, the objective of the study, scope and limitations. The rest is organized as described next.

Chapter 2 covers the literature review and the previous methods of detecting moisture content of the fruit, food, material and others. Brief summary is provided from a study of more than 150 research papers.

Chapter 3 presents the pineapple biology and other relevant issues such as definition of the sweetness and ripeness from the biochemical and physiochemical perspective.

Chapter 4 presents several configuration of selected microwave sensors. In addition to that the proposed sensor is presented with its operation experimental setup and procedures.

Chapter 5 presents of the methodologies used to predict moisture content of a set of pineapple samples, measurement of the PH, the conductivity, and analysis the data.

Chapter 6 presents the results in detailed for each configuration. Analysis are made.

Chapter 7 are concludes the work and also given suggestions for future work.

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