Ripeness Inspection System for Banana

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ABSTRACT
Ripening is the process by which fruits attain their desirable flavour, quality, colour and other textural properties. Bananas are the most popular fruit in the world. India and Brazil are first and third largest banana producers for sale in local markets, that provide households with regular income throughout the year. Automatic control of environmental conditions is an important problem of banana ripening treatment. In this study, a capacitive sensing system was designed and developed. In this method banana fruit is placed in the capacitive sensor as a dielectric material and then the capacitance of sensor is measured. Experiments were carried out with 10 kHz to 10 MHz sinusoidal frequencies. A consistent decrease of εb had occurred at 100 kHz and 1 MHz frequencies when banana had been ripened. A high correlation was observed between εb and ripening period at 100 kHz frequency. This system has the following characteristics: rapid response, simple operation, nondestructive measurement, and low cost. This method shows that for uniform size banana, as ripeness changes there is change in the capacitance.

Keywords
Capacitive Sensor, Ripeness

1. INTRODUCTION
The characterization of fruits has been an important issue in the automatic sorting of fruits from the harvest site as well as from the cool storage. The quality of the fruits, at the time of consumption, also depends on the maturity stage reached at the time of harvest. Fruit Characterization techniques is divided into two groups, i.e. non-destructive and destructive techniques. For automatic sorting of fruits, with the help of robotic arms, generally, non-destructive techniques are preferred. Non-destructive techniques based on ultrasonic, optical, microwave, image categorization and semiconductor sensors have been used successfully for the testing of fruits, for commercial purposes.On the basis of ripening behaviour, fruits are classified as Climacteric and non- Climacteric fruits. Climacteric fruits are defined as fruits that enter 'climacteric phase' after harvest i.e. they continue to ripen. During the ripening process the fruits emit ethylene along with increased rate of respiration. Ripe fruits are soft and delicate and generally cannot withstand rigors of transport and repeated handing. These fruits are, therefore, harvested hard and green but near full maturity and are ripened near consumption areas by using ripening aid. Even fully mature fruits of this category may be ripened by using ripening aid to get uniform ripening in large lots for bulk transport and marketing. Small dose of ethylene is used to induce ripening process under controlled conditions of temperature and humidity. Climacteric fruits are mango, banana, papaya, guava, sapota, kiwi, persimmon, fig, apple, passion fruit, apricot, plum and pear. Non-climacteric fruits once harvested do not ripen further. Non-climacteric fruits produce very small amount of ethylene and do not respond to ethylene treatment. There is no characteristic increased rate of respiration or production of carbon dioxide. Non-climacteric fruits are citrus, pineapple, grape, strawberry, pomegranate, litchi, watermelon and cherry.Ripeness is currently assessed visually by comparing the peel colour of banana with standardized colour charts that describe various stages of ripeness. In trade market, seven ripening stages of bananas are usually discerned. Colour stage is judged visually by using a chart scale provided to categorize banana based on its level of ripeness (Figure 1.1). On the first day banana fruits were at stage one (0% ripened) and on the fifth day, they were at stage six (100% ripened).

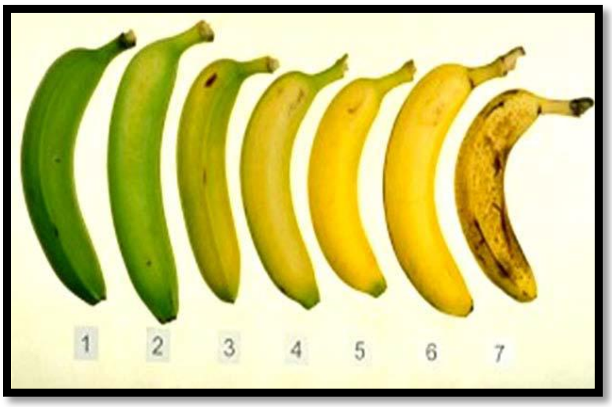

Figure 1.1 Ripeness stages of banana

To control the condition of banana ripening treatment and having a good ripened banana fruit, an expert person is needed for determining the level of banana ripeness. Sometimes, banana fruits do not reach to full-ripe step and so the green spots remain on the peel of banana. This problem is because of manual controlling of ripening treatment. To achieve a good ripening, an online controlling system is essential. This work aims to design and develop a device to monitor the ripeness level of banana fruit during ripening treatment and control ripening conditions such as temperature, air moisture content and ethylene concentration. Firmness is a very good indicator in determining the quality of products, and it has been used to measure maturity and ripeness of fruit. A penetrometer is used to measure firmness of fruits and it is a destructive method. Peel colour is considered as a good indicator of banana ripeness as the chlorophyll content in the peel reduces with banana ripening. The 1st observable sign of ripening is a colour change from green to yellow. There are seven stages of banana colour during ripening and retailers usually sell banana fruits when they are at stage six. This method is based on human visual determination that can be imprecise and insufficient to assess the internal quality changes. Therefore, it is important to assess banana ripeness through an inexpensive, fast and non-destructive approach. Dielectric spectroscopy is relatively a new method applied to agricultural produce. Dielectric parameters used to characterize materials are dielectric constant, permittivity, dielectric loss and impedance. The choice of parameters depends on the suitability of materials and equipment available. Dielectric is also used for studying the structures of organic and inorganic materials with wide and continuous frequency impedance measurement. The dielectric properties of nine types of fresh fruits and vegetable were studied over the frequency range from 10MHz to 1.8GHz and over the temperature range from 5 to 65°C. Further research was carried out to find correlation between soluble solids content, indicative of sweetness, and the permittivity of honeydew melons for quality sensing. The relative permittivity of fresh soybean decreases as the bean matures. Since dielectric based sensing showed potential use in wide agricultural products, this research was done to study the dielectric characteristic of banana at different ripeness using impedance measurement. The impedance value was then correlated with the soluble solid content (SSC) to develop model to predict SSC value based on impedance measurement for ripeness determination.

2. METHODOLOGY

Most of the traditional methods for assessing fruit ripeness are destructive and thus can't be applied. Some of these methods measure fruit firmness by using a penetrometer or an impact force. Other strategies measure chemical levels and parameters correlated to ripeness such as pH, titratable acidity, soluble-solids content, and ethylene content. Measuring these chemical species and parameters generally requires destroying the fruit and applying complex analytical techniques, such as gas–liquid chromatography (ethylene) and titration (acidity).More recently, non-destructive methods of determining fruit ripeness have emerged. These methods include nuclear magnetic resonance (NMR) and proton magnetic resonance (PMR) to determine soluble-solid levels, vision systems to determine the skin colour of the fruit, and acoustic methods to determine firmness. However, these approaches have inherent issues because NMR and PMR techniques rely upon expensive equipment, and fruit colour and ripeness are not always correlated. An attractive alternate method for determining fruit maturity levels uses a parallel plate capacitor. During ripening, extensive changes may occur in the cell wall, membranes and the composition of the cell contents. All of these changes would affect the capacitance of the tissues. If the permeability of membranes around the cytoplasm were affected in such a way as to eliminate ionic polarization in the region of the membrane, large changes in capacitance would occur. Effects on membranes and interfaces could be a major cause of changes in electrical capacitance in fruits. Interpretation of electrical properties gives a chance to study the behavior of fruits maturity.

3. WORKING

3.1 System Block Diagram

To understand the whole system in the simplicity way lets observe the block diagram as displayed in Fig. 3.1 where Capacitive sensor is designed by using copper plates having dimensions 20 * 9 cm. Banana fruit sample as a dielectric placed between copper plates. Electronic circuitry consists of bridge circuit made of 4 diodes which converts capacitance value into a dc level which is fed to the PIC18F4550. PIC 18F4550 has in-built ADC (13 channel, 10 bit). Measuring of ε_b initiates after the Fruit is placed through capacitive sensor on two small brackets. All voltage measurements, calculations and analysis operations are done by microcontroller and then results of ripeness estimation are shown on the display.

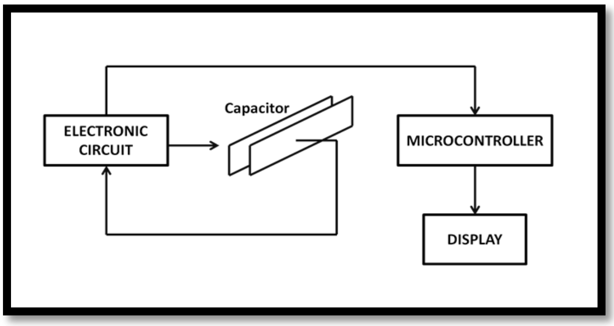

Figure. 3.1 Block diagram of Ripeness Inspection System

3.2 Constructional Detail

3.2.1 *Capacitive Sensing Unit*

Capacitance describes the ability of capacitors to store energy and electrical charge. The presence of a dielectric material in capacitors causes an increase in the capacitance value. The values of the effective capacitance will depend upon the structure of the fruit. Effective values are taken because it will not be pure capacitance but combination of capacitances because of the complex nature of the equivalent circuit. These will be different when measured for raw, ripe and over ripe fruits of nearly same size because capacitances offered by skin, pulp and seed of the fruit will be different in different conditions. Hence, raw and ripe fruits may be characterized in terms of their effective capacitances. Optimum frequency, at which maximum difference among capacitances of raw, ripe and over ripe fruits may be achieved, may be assessed by determining their effective capacitance vs. frequency characteristics in the frequency range of 1–200 kHz.

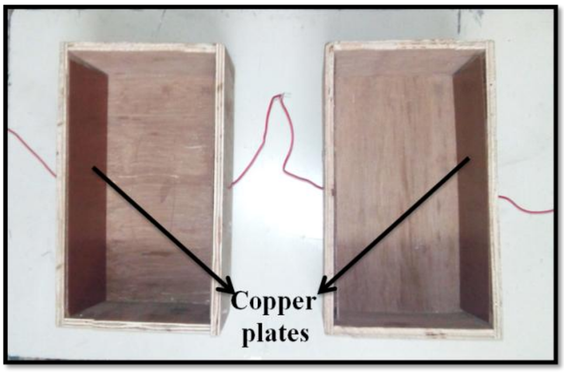

Figure 3.2.1 Capacitive Sensing Unit

In order to predict the ripeness percent of banana fruit, an electronic unit was designed and developed. The electronic device for ripeness measurement has four components: two rectangular parallel plate capacitor, electronic circuitry, microcontroller, and display. To measure capacitive properties of banana, a rectangular parallel plate capacitor with 20 cm in length and 9 cm in width was constructed as a standard hardware instrument. The conductive plates were selected from copper materials.Fruit banana is chosen for this study because its color reflects its maturity level and bananas are widely available, in all the seasons. The sample banana, fell into four maturity level categories: under-ripe, unripe, ripe, and over-ripe. All samples were between 3 cm and 4 cm in diameter.

3.3 Circuit Diagram

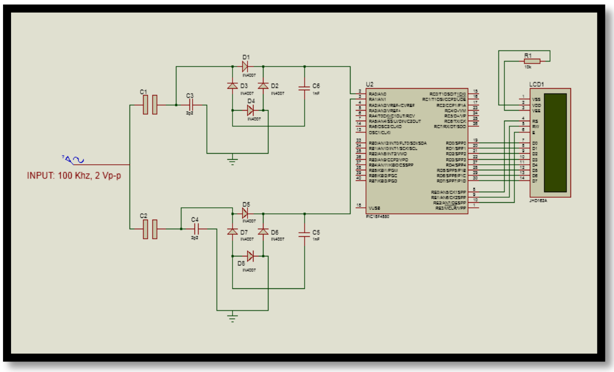

Fig. 3.3 Circuit diagram of Ripeness Inspection System

Figure shows circuit diagram for predicting the ripeness stage of banana fruit. The PIC microcontroller is the heart of the system. The PIC converts analog voltage to digital voltage, estimates ε_b and hence of banana ripeness level. The output voltage from sensor is converted to DC current by a diode bridge, and then the A/D unit of PIC measures the output voltage. The system had been calibrated by experiments performed with standard capacitors previously and relation between measured voltage and capacitance was extracted. Finally the results of banana ripeness prediction are displayed on a 16×2 characters LCD.

4. ALGORITHM: FRUIT ANALYSIS

1. Function generator is set for 100 kHz frequency, 2 volts peak-to-peak amplitude sinusoidal wave.
2. Positive terminal of the function generator is connected to the capacitor marked “transmitter” and ground terminal to the point M.
3. Voltage is measured across the points A and M (standard capacitance) and points B and M (fruit capacitance).
4. Initialize the microcontroller, Initialize the LCD, and observe the voltage.

5. SYSTEM IMPLEMENTATION

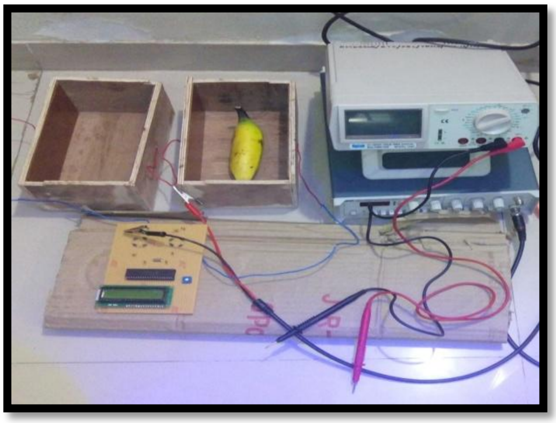

Fig. 4.1 Experimental Setup of Ripeness Inspection System

6. RESULTS

5.1Observation Table

Sr no.	Date & Time	Standard capacitance	Fruit capacitance	Voltage across Capacitors (V) C1	C2
1	25/03/15 9:40 pm	0.124	0.018	10.23	10.76
2	26/03/15 8:00 pm	0.05	0.06	11.45	12.06
3	27/03/15 8:00 pm	0.06	0.05	12.60	12.96
4	28/03/15 9:00 pm	0.06	0.05	13.80	13.80
5	29/03/15 9:00 pm	0.10	0.012	14.40	14.32
6	30/03/15 8:00 pm	0.015	0.017	14.40	14.32

5.2 Graphical Analysis

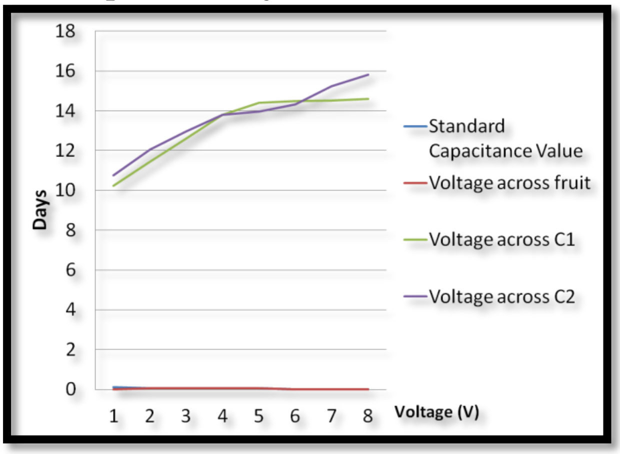

Figure 5.2.1: Graphical Analysis of Fruit

The graph shows relationship between ripeness of fruit over a period of days (Y-axis) and voltage across fruit (X-axis). From the graph we observe that as the ripeness of the fruit changes every day the output voltage changes linearly. Once the fruit is ripe completely the voltage remains constant.

7. CONCLUSION

A low cost device for predicting the ripeness level of banana fruit was designed and built. This unit estimates the ripeness level of banana by its dielectric constant. The designed system can predict the ripeness level of banana fruit reliably. Dimensions of sample had a direct effect on capacitance. A capacitance sensing system was equipped by a pairs of parallel plate capacitor sensor. This project studied the ability of this method to predict the quality of bananas during ripening period. Results showed that this technique, which is based on dielectric property, was able to assess changes in the quality parameters of banana fruits during ripening period. From this experimentation it can be concluded as ripeness of any fruit, of uniform size, is directly proportional to capacitance across the fruit.

8. APPLICATIONS

- The condition of ripening room such as temperature, humidity can be controlled automatically.
- Ripening period of any fruit can be evaluated.

9. FUTURE SCOPE

- System can be designed to monitor and control other parameters like sugar, glycerine and potassium contents in fruits.
- Intelligent Colour Vision System.
- Non-destructive Testing and Evaluation.
- Measurement of fruit sweetness content.
- Detection of Artificial Ripening of fruits.

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