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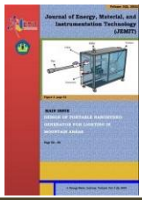

Design of Measurement of Water Content with Capacity Method to Determine Old Categories to Save Tapioca Flour

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Abstract

In this study, water content measurements were carried out using a physical method using a capacitive sensor. Measurement with these two methods aims to get the most efficient method for tapioca flour's water content value. The samples used were six samples of tapioca flour from the way good factory. Each sample was measured using a thermogravimetric method and a capacitive sensor measuring instrument three times per sample. The measurement results produce a polynomial graph with a coefficient of determination of 0.9702. The graph shows that the higher the water content, the higher the value detected by the capacitive sensor. The thermogravimetric method used as a reference takes 6 hours to get results, and the physical method takes less than one minute. To compare measurements, measurements were made using the thermogravimetric method to measure the percentage of water content in tapioca flour. This study indicates that the physical measurement method with a capacitive sensor instrument requires a shorter time than the thermogravimetric method. And the higher the water content, the shorter the storage time.

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Abstrak

Pada penelitian ini dilakukan pengukuran kadar air dengan metode thermogravimetri dan metode fisis menggunakan sensor kapasitif. Pengukuran dengan dua metode ini bertujuan untuk mendapatkan metode yang paling efisien dalam mendapatkan nilai kadar air tepung tapioka. Sampel yang digunakan berjumlah 6 sampel tepung tapioka yang berasal dari pabrik way kanan. Masing-masing sampel tersebut diukur menggunakan metode thermogravimetri dan alat ukur sensor kapasitif sebanyak 3 kali per sampel. Sebagai pembanding dalam pengukuran, telah dilakukan pengukuran dengan metode termogravimetri untuk mengukur persentase kadar air dalam tepung tapioka. Hasil pengukuran tersebut menghasilkan grafik polinomial dengan dengan nilai koefisien determinasi sebesar 0.9702. Grafik karakterisasi menunjukkan bahwa kadar air tepung tapioka berbanding lurus dengan nilai output dari sensor kapasitif. Metode thermogravimetri yang digunakan sebagai referensi memerlukan waktu 6 jam untuk mendapatkan hasil, dan metode fisis memerlukan waktu kurang dari satu menit. Hasil dari penelitian ini menunjukkan bahwa semakin tinggi kadar air maka semakin singkat waktu simpan.

1. Introduction

All foodstuffs contain water as an essential element, even though it is not a source of nutrients, its presence is essential in the continuity of the biochemical processes of living organisms. Water in foodstuffs exists in various forms, such as free water, weakly bound water, and firmly bound water. Free water can help the process of food damage, such as microbiological, chemical, and enzymatic processes, even by the activity of destructive insects. At

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the same time, water in other forms does not help the process of damage to foodstuffs. The water content is expressed in percent (%) with a scale of 0-100 (Winarno, 2004).

The water content in food can be determined in several ways, namely: determination of water content by drying (thermogravimetry), determination of water content by distillation (thermos-volumetry), determination of water content by chemical method, and determination of water content by physical method. Thermogravimetry has the principle of determining water content by evaporation of water present in the material by heating. Then the material is weighed to a constant weight which indicates that all the water contained in the material has evaporated. Determination of water content in this way is relatively easy and economical. However, according to the 1995 *Official Methods of Analysis (AOAC), this method requires a heating temperature of 105* °C for 6 hours.

Thermo-volumetry is a distillation method used especially for materials that contain lots of fat and volatile components besides water. The samples tested using this method have the same properties as those used in the vacuum-oven method. The method of determining water content by chemical methods commonly used is the Karl Fischer titration method. This method is used to measure the water content of materials such as liquid, flour, honey, and some dry products. As the name implies, this method uses a Karl Fischer reagent consisting of SO_2, pyridine, and iodine. The principle of this method is to titrate the sample with a solution of iodine in methanol and pyridine.

Determination of the water content of the physical method uses changes in the physical value of a material to determine the water content contained in it. The physical values that can be used can be changes in capacitance, changes in resistance, and nuclear magnetic resonance. This method does not require additional materials to determine the water content, and simply by inputting the sample into the measuring instrument, the results will come out right away (Winarno, 2004).

Some of the methods of determining water content that has been mentioned have advantages and disadvantages depending on the sample being measured. The category of tapioca flour is easier to measure using the thermogravimetric method and the physical method of determining the moisture content. However, thermogravimetry takes 6 hours for efficiency until the results can be displayed, while the physical method can be displayed directly after the measurement (Winarno, 2004).

Tapioca flour is a food ingredient derived from dried and mashed cassava tuber starch. Cassava that has been processed into tapioca flour can last for 1-2 years in storage if packaged properly (Tarwiyah, 2001). The basis for determining the quality of tapioca flour is the level of whiteness, the level of fineness (mesh), the remaining water content, and the content of harmful elements. The remaining water content generally ranges from 12-to 15%. The water content of tapioca flour can change because it absorbs water from the air and is contaminated with water or dew. Water content above 15% causes tapioca flour to become moist so that it quickly breaks down such as becoming acid, overgrown with fungus, clumping, and others (Suprapti, 2005).

Tapioca flour produced must be stored immediately after entering the packing stage because moisture and high humidity in the air will affect the quality of the flour, especially for microorganisms that are susceptible to life when the water content is high. Determination of this water content will affect the flour storage process. If the manufacturer uses the Thermogravimetric method, the production quality can be known after 6 hours of testing. This time is quite long compared to the physical method, while flour must be categorized based on its quality and category of shelf life.

Based on these problems, the authors conducted research on measuring the water content of tapioca flour using physical methods with capacitive sensors to overcome this problem. So flour can be known for the moisture content right after production so that the storage process can be carried out effectively.

2. Research Methods

This research is divided into software *design*, *hardware* design, and tool testing. The tools and materials used in this study were digital scales, multimeter, Arduino IDE, PC, USB Serial cable, power supply, tapioca flour, Arduino nano, LCD Nokia 5110, jumper cables, and capacitive sensors. The capacitive sensor used is included in the type of analog sensor.

2.1 Software Design

Software design using Arduino IDE 1.8.5 *software*. The first thing to do is create and update a program containing program *interface data* and water content calculations to store them in Arduino storage or memory. This is done so that when using the power supply*,* Arduino directly displays the data in its storage to the Nokia 5110 LCD. The data displayed is the amount of water content and the category of storage time. The software design water diagram can be seen in Figure 1.

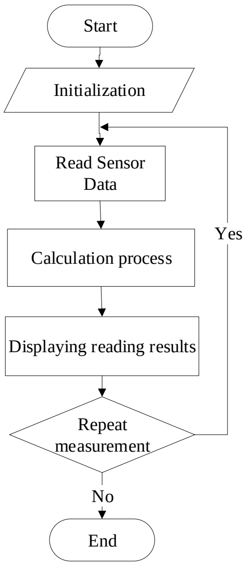

Figure 1. Software design flowchart.

2.2 Hardware Design

Hardware design is the stage of compiling electronic components into a single system so that they can work as expected. In general design, the hardware is shown in the block diagram in Figure 2 and the overall circuit schematic in **Figure 3**. The hardware consists of a capacitive sensor module, an Arduino Nano microcontroller, a Nokia 5110 LCD, cables, and a 5V 1A power supply. The sensor is characterized by flour that has been measured by the thermogravimetric method to ensure that the sensor works well. Characterization is done by looking for a relationship between the results of the thermogravimetric method of measuring water content with the signal value of the capacitive sensor measurement results in the form of a voltage value (mV). The resulting equation from the characterization is used to calculate the water content value in the Arduino program. The characterization graph is shown in **Figure 5**.

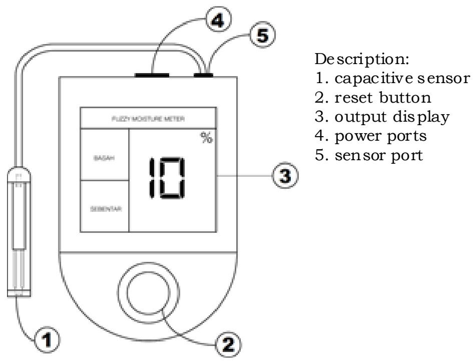

Figure 2. Hardware design.

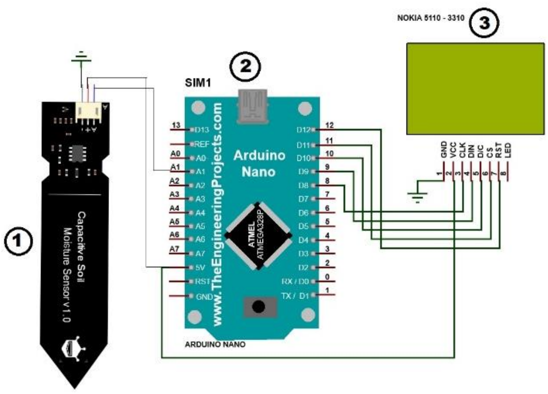

Figure 3. Schematic of the whole circuit. (1) Capacitive sensor, (2) Arduino Nano, (3) Nokia 5110 LCD.

2.3 Data Collection

The data in this study are the physical method of measuring water content with a capacitive sensor. The results of the research data collection are shown in **Table 1.** The results of the observational data obtained in the study analyzed how the effect of water content on the value of the capacitive sensor. As measured by the instrument, the water content of tapioca flour was known beforehand by measuring the thermogravimetric method by the Research and Industrial Standardization Institute of Bandar Lampung. Variations in tapioca flour moisture content to sensor values are displayed, and data analysis is plotted in graphical form, as shown in **Figure 4.**

3. Results and Discussion

3.1 Realization of Water Content Measuring Devices with Capacitive Sensors

The tool has been realized water level meter with a capacitive sensor. The realization of this water content meter aims to measure the water content quickly and display the category of flour storage time being measured. The realization of the tools used in this study can be seen in **Figure 4**.

Figure 4. Realization of water content measuring device with capacitive sensor.

3.2 Data Collection

From the research that has been done, the data obtained from the relationship between water content as measured by the thermographic method and sensor values capacitive as in **Table 1.**

3.3 Water content test by thermogravimetric method and physical method with capacitance sensor

The water content test using the thermogravimetric method was carried out by the Bandar Lampung City Research and Industrial Standardization Center. The test was conducted using thermogravimetric and physical methods with a capacitance sensor. The tested samples were stored in tightly closed plastic bags to minimize contamination with room air humidity. The test results came from 6 samples which were tested three times. These results can be seen in **Table 1**. The water content test using the physical method with a capacitive sensor was carried out with the same sample and amount. One sample was tested three times and shown in **Table 1**.

Table 1 . Tool Measurement Characterization

Sample to-	Thermogravimetric Result Moisture Content (%)	Sensor Value (mV)			Average (mV)
		First	Second	Third	
1	5	52	52	52	52
2	6	54	54	54	54
3	10	57	57	57	57
4	11	64	64	64	64
5	12	74	74	74	74
6	14	86	86	86	86

3. 4 Data Analysis

This study conducted data collection to determine the characterization of capacitive sensors based on changes in water content in tapioca flour. Each change in the water content of flour will change the value of the dielectric permittivity, which affects the change in the value of the voltage sent by the capacitive sensor to the Arduino Nano microcontroller. This change in voltage is referred to as an analog signal. The received analog signal is then converted into digital form by the ADC. The resulting ADC value is converted to Volts. The significant change in this signal can be seen in **Table 1**. Based on expert opinion from the Research and Industrial Standardization Center of Bandar Lampung, the category of shelf life of tapioca flour is based on its water content. The analysis can be seen in **Table 2**.

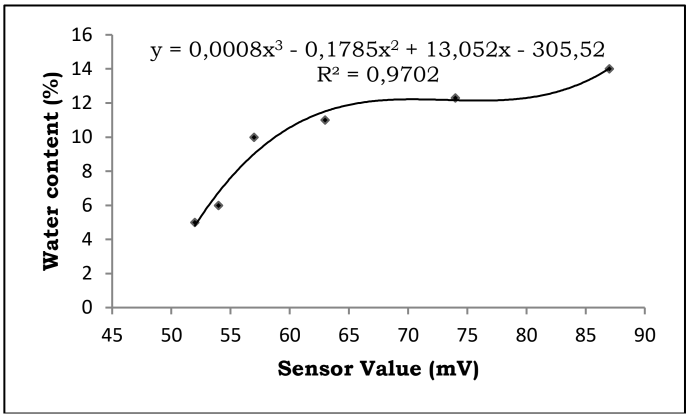

Figure 5. Water content graph vs the capacitive sensor value

The water content value in tapioca flour is directly proportional to the value of the capacitive sensor. **Figure 5** shows a polynomial graph between the water content and the sensor value (mV). The graph of the relationship between the percentage of water content and sensor measurements obtained a coefficient of 0.9702. The equation from the graph is used to determine the value of the moisture content and the category of storage time by being included in the Arduino data processing. The storage time used is based on the plastic valve packaging. The output results of these calculations are displayed on the LCD screen of the Nokia 5110, as shown in Figure 5. Conclusion of the moisture content calculation of tapioca flour is classified in **Table 2**.

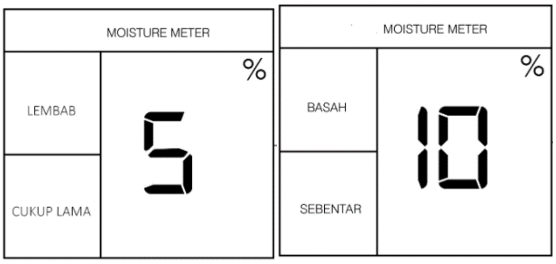

Figure 6. Display output for measuring the water content of tapioca flour.

Table 2. Characteristics of Moisture Content Based on Sensor Readings (according to the expert opinion of the Research Institute and Industrial Standardization)

No	Category	Water content (%)	Sensor Value (mV)	Save Time Category
1	Dry	0-5	0-50	Old (6 Months)
2	Moist	5-10	51-60	Long Enough (4 months)
3	Wet	10-15	61-90	Soon (2 months)
4	Very wet	>15	> 90	Very Short (10 days)

The category of storage time used is based on expert opinion at the Research and Industrial Standardization Institute. The "long" shelf life category means flour can be stored for six months. The "long enough" storage time category means flour can be stored for four months. The "short time" storage category means that flour can be stored for two months. The "short" storage time category means that flour can be stored for ten days. With a short storage time, Tapioca flour has a higher potential for the growth of microorganisms and fungi because its water content exceeds the SNI standard (>15%).

4. Conclusions

Based on the results and discussion obtained by measuring the water content using a capacitive sensor. It takes less than a minute. At the same time, the thermogravimetric method takes 6 hours. The category of storage time and water content of tapioca flour resulted in a relationship the higher the water content of the flour, the shorter the shelf life.

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