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IoT Based: Improving Control System For High-Quality Beef in Supermarkets

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***Abstract*—Supermarkets are modern markets that sell various household needs ranging from equipment items to various food products, one of which is beef. Consuming beef can have good or bad effects depending on the quality of the freshness of the beef itself. Therefore, before the beef is sold and consumed by the customer, it is necessary first to control the quality of the freshness of the beef. In supermarkets, the process of controlling the quality of beef still uses manual methods, so that the output produced is inaccurate and requires a long time. The presence of IoT technology can overcome these problems, so the process of controlling the quality of beef can be faster and more accurate. In this study, the controlling system is proposed to identify the quality of freshness of beef, the quantity of beef and temperature control in the sales rack. This controlling system utilizes NodeMCU microcontroller, three gas sensors (MQ-136, MQ-137, and TGS-2602), TCS-3200 color sensors, LED lights, buzzers, HC-SR04 ultrasonic sensors and LM35 temperature sensors. The workings of this system are to detect the gas and color produced from the beef and detect the temperature and presence of beef on each side of the rack. It can be concluded that the success of the proposed system has fairly good representation, in accordance with the theory regarding the level of freshness of beef that already exists.**

Keywords— IoT, Supermarkets, High-Quality Beef

I. INTRODUCTION

Supermarkets are a modern market that sells a variety of household needs, such as supplies and food products. Quite a number of consumers choose to shop at supermarkets compared to traditional markets for various reasons such as the level of cleanliness of the place, the quality of the product and the level of hygiene of the meal. This is one of the considerations and a special attraction for consumers.

Beef is one of the food products found in supermarkets and is one of the products purchased by consumers. Beef has high nutrition because it contains carbohydrates, proteins, fats, vitamins and minerals [1]. High nutritious beef is beef that is still fresh and has good quality. If the beef is not fresh and smelly, then the beef is no longer suitable for consumption because it can have a negative impact on the health of consumers. With these conditions can lead to decreased purchasing power and consumer confidence in supermarkets. In order to maintain the quality of beef freshness, the supermarket must control the quality of freshness of the meat at all times. The current system control in supermarkets still uses a manual system, namely by checking one by one the texture of beef directly. This method requires a long time process and tends to be inaccurate in determining the quality of freshness of beef.

With the rapid development of technology, many new technologies can be utilized, one of which is the Internet of Things (IoT) based technology. IoT technology is one technology that combines the internet and things or things that are connected to each other [2]. IoT technology utilizes several sensor components, microcontrollers and internet networks. Looking at the background of the problems that occur in supermarkets can be proposed a system controlling the quality of IoT-based beef in supermarkets.

The system proposed in this study is to use three gas sensors (MQ-136, MQ-137 and TGS-2602) that can detect gas released by beef. TCS-3200 color sensor to detect RGB color texture conditions produced by meat cow. HC-SR04 ultrasonic sensor to detect the quantity of beef put into the sales rack and LM35 temperature sensor that is used to detect the condition of the rack selling temperature of beef. The proposed study aims to assist the process of controlling the quality of freshness of beef sold in supermarkets and the quantity of beef contained in the sales rack so that the quality of freshness of beef is maintained.

II. RELATED WORK

A. Beef Freshness

Viewed from the point of view of the benefits of consuming beef itself can increase the body's immune system, can maintain ideal body weight and many other benefits obtained when consuming beef regularly. Based on color, smell and texture can be used to determine the quality of beef. The smell or smell of beef comes from the content of volatile organic compounds (VOC) contained in beef. Beef is the best medium for microbial growth which can reduce the quality of beef. The number of microbes in beef can determine the level of freshness of beef and the storability of beef [3]. The decay of beef is caused by microbial activity that releases intracellular extracellular enzymes. The level of decay of beef is based on changes in color and aroma, texture, and gas formation [4].

B. Sensors

To find out the quality of food can use sensors and microcontrollers. From several previous studies, there were various methods used to detect food quality, including a system that was proposed to detect the freshness quality of beef based on ammonia gas with a TGS-826 sensor [5] gas SnO2 [6] and RGB colors produced by beef with TCS-3200 sensors [4]. Besides that, there is also a paper that makes the system to detect the quality of packaged foods to avoid poisoning because it has expired especially household food [7] and a system for detecting the freshness of fish meat [8]. In the paper Y. H. Kim *et al*. (2018), explained the system for detecting apples using colorimetric sensors [9] [10] [11] which can detect aldehydes in solution and steam. In addition to colorimetric sensors, there is also an optical sensor for detecting fruit maturity [12]. In the paper L. A. Greenawald *et*

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al. (2017), discussing the use of color sensors in detecting ppm concentrations of low hydrogen cyanide gas [13]. In the paper K. Adi *et al*. (2017), the system for detecting the quality of meat through a smartphone camera by processing meat images based on color and shape using the k-means clustering method [1].

In addition to detecting the quality of food, there are other papers that discuss methods for knowing the quantity of food contained in food places by using an ultrasonic sensor [14] [15] [16]. By knowing the quantity contained in food storage, the temperature can be adjusted in that place. This is closely related to the temperature of the storage in the supermarket so that the quality of the food is maintained and suitable for consumption. To find out information on the temperature of the meat storage in general, the system using a temperature sensor [17] [18] [19].

C. Internet of Thing

Internet of Things (IoT) is a concept where certain objects have the ability to transfer data over a network without requiring interaction from human to human or from human to computer device [20]. Some papers use IoT to identify food quality [7], beef quality [3], fish quality [8] and others. IoT is used as a link between devices and humans globally and can be accessed everywhere [21]. IoT has now grown rapidly and has reached various fields and lines of human life because many things are manually changed into something automatic.

The design and architecture proposed in this paper use one NodeMCU esp8266 controller, three gas sensor sensors (MQ-136 gas sensor, MQ-137 sensor, and TGS-2602 gas sensor), one TCS-3200 color sensor, six HC-SR04 ultrasonic sensors, one LM35 temperature sensor, three LED lights (green, yellow and red), and a buzzer. The architecture of the system controller is as follows :

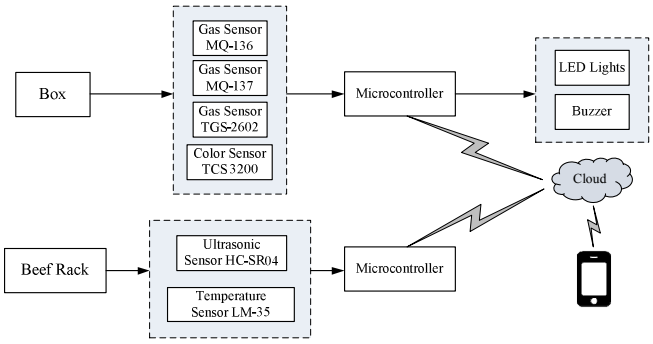

Fig. 1. System Architecture

In figure 1 shows the system architecture for detecting the quality of beef. The first is a box that has three gas sensors, one color sensor, three LED lights, and one buzzer. This gas sensor will detect gas produced by beef, and the color sensor will detect the color produced by beef. For LED lights and buzzers will light up according to the freshness conditions of each of the beef. The results of the information from the sensor will be forwarded to the NodeMCU microcontroller to be processed. After the information is processed in NodeMCU, the information will be sent to the user's smartphone for further action. The second is a meat storage rack; this meat storage rack has six ultrasonic sensors and one temperature sensor. These two sensors will send quantity information on beef and temperature conditions contained in the meat storage rack. This information will be received by the NodeMCU microcontroller to be processed and sent to the user's smartphone for information.

The design of the controlling system is divided into 2, namely the design in the box and the design in the sales rack. The first design is a design box explaining the placement of sensors that will be used to determine the quality of beef. The design of the box is as follows :

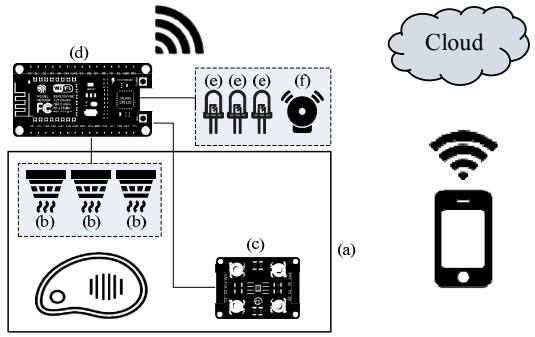

Fig. 2. Beef Detection Box

Figure 2 shows the box (a) design to detect beef. The three gas sensors (b) are placed at the top of the box and the color sensor (c) in the inside of the box, for the NodeMCU microcontroller (d), the LED light (e) and Buzzer (f) are placed on the top of the outside box. The workings of this box are, first, the beef is put into a box that is closed, and the color sensor is affixed to the meat and then left for a few seconds until the sensor detects gas and the color produced. Then the LED light (e) will automatically turn on according to the condition of the beef, and the buzzer (f) will sound if the condition of the beef is not suitable for consumption.

The second design is the shelf design of beef sales in supermarkets. This design explains the placement of sensors in the rack. Images from the storage rack design are as follows:

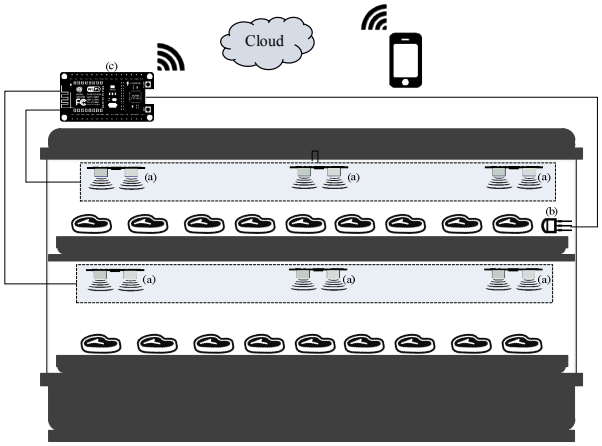

Fig. 3. Beef Rack Sale

Figure 3 shows a rack design of beef sales commonly found in supermarkets. The ultrasonic sensor (a) is placed on the side and top of each rack, and for one temperature sensor (b), one is placed inside the rack where the meat is sold. Each sensor will be connected to the NodeMCU (c) placed at the top right of the meat sales rack.

III. Result and Discussion

A. Testing of Beef Detection Box

In the testing phase of meat quality, there are several types of beef conditions, namely beef that is still fresh, then less fresh beef and beef which are already in the process of decomposing all these conditions are based on theoretical knowledge with existing criteria. Where each condition of the meat will emit gas frequencies and different color characteristics so that these differences become information captured by the sensor. The third beef with these conditions is then tested one by one into the box to obtain the same results as the existing theory. Furthermore, it can be concluded that the value of the system accuracy is obtained by the theory of each sensor, based on each selected meat condition. In this stage, using three gas sensors (MQ-136 gas sensor, MQ-137 sensor, and TGS-2602 gas sensor), one TCS-3200 color sensor.

1) Testing of Gas Sensors: The gas sensors used in the proposed system are MQ-136 gas sensor, MQ-137 sensor, and TGS-2602 gas sensor. Each sensor has its own use. The MQ-136 gas sensor is used to detect the concentration of H2S gas in the air, which is treated by beef. The MQ137 sensor is specifically designed to detect the presence of NH3 gas in the air which is treated by beef. And the TGS-2602 gas sensor is used to detect low concentrations of gas such as ammonia and H2S which are released by beef. From each condition of the meat, each meat emits gas, which has a different voltage. The gas voltage will be detected by each sensor to determine the level of quality of the freshness of the meat. The gas voltage range in table 1 is based on research Rivai *et al.* (2018) from each level of quality of freshness of meat [4].

TABLE I. Voltage Range [4].

Beef Quality	Voltage Range		
	MQ-136	MQ-137	TGS-2602
Fresh Quality	1.83-2.18	1.96-2.06	1.74-2.09
Less Fresh Quality	2.58-2.96	2.26-.2.44	1.98-2.34
Rotten Quality	2.47-2.8	3.04-3.14	2.17-2.3

Based on table 1, the quality of beef is divided into 3, namely fresh quality, less fresh quality and rotten quality. The voltage range with the fresh quality produced by beef using the MQ-136 gas sensor is 1.83 to 2.18, whereas the MQ-137 gas sensor is 1.96 to 2.06. And by the TGS-2602 sensor is 1.74 up to 2.09. The gas voltage range of the less fresh quality of beef detected by the MQ-136 gas sensor is 2.58 to 2.96. The MQ-137 gas sensor is between 2.26 to 2.44, and the TGS-2602 gas sensor is between 1.98 and 2.34. For the voltage range with the quality of beef rot from the gas sensor MQ-136 is between 2.47 to 2.8. The MQ-137 gas sensor detects the voltage 3.04 to 3.14 and for the TGS-2602 sensor is between 2.17 to 2.3.

2) Color Sensor Testing: The color sensor used in the proposed system is the TCS-3200 color sensor. This sensor is used to detect the color characteristics of beef. The color sensor will respond to the color of beef by taking the RGB value of the color of the meat being tested. The color of each beef has different color characteristics according to the level of freshness of the meat itself. In general, fresh beef has a bright red color, while less fresh meat will have a rather dark red color. This color sensor works by detecting the level of similarity of the colors Red, Green and Blue (RGB) with the color conditions found in beef. Table 2 shows a color range and beef quality based on research Rivai *et al*. (2018) [4].

TABLE II. Color Range [4]

Beef Quality	Color Range (RGB)		
	Red	Green	Blue
Fresh Quality	68-83	21-35	19-30
Less Fresh Quality	48-58	20-28	17-25
Rotten Quality	33-47	19-29	17-27

Each quality of beef will present different levels of color similarity with RGB colors according to the conditions of each beef. As in table 2, fresh quality meat has a higher RGB color level compared to the color possessed by the quality of less fresh beef and rotten beef.

After testing the meat quality detection box consisting of a gas sensor and color sensor, the accuracy of the system is 86% with the existing theory.

3) How the gas sensor and color sensor work: Data generated by the gas sensor and color sensor will produce the condition of each meat that has gone through the meat detection box. Where if the MQ-136 sensor detects the gas produced beef with a voltage between 1.83-2.18, the MQ-137 sensor detects the gas produced beef with a voltage between 1.96-2.06, the TGS-2602 sensor detects the gas produced by beef with a voltage between 1.74 -2.09, the TCS-3200 sensor detects the condition of the red color produced by beef between 68-83, the green color produced by beef between 21-35, the blue color produced by beef 19-30 then the meat can be declared as fresh.

Furthermore, if the MQ-136 sensor detects a gas produced beef with a voltage between 2.58-2.96, the MQ-137 sensor detects a gas produced beef with a voltage between 2.26-.2.44, sensor TGS-2602 detects a gas produced beef with a voltage between 1.98-2.34, the TCS-3200 sensor detects the condition of the red color produced by beef between 48-58, the green color produced by beef between 20-28, the blue color produced by beef 17-25 can be stated that the meat is in less condition fresh.

Meanwhile, if the MQ-136 sensor detects a gas produced beef with a voltage between 2.47-2.8, the MQ-137 sensor detects a gas produced beef with a voltage between 3.04-3.14, the TGS-2602 sensor detects a gas produced beef with a voltage between 2.17-2.3, the TCS-3200 sensor detects the condition of the red color produced by beef between 33-47, the green color produced by beef between 19-29, the blue color produced by beef 17-27, it can be stated that the meat is already rotten.

B. Implementation of Quantity Calculations

The sensor used in calculating the quantity is the HC-SR04 ultrasonic sensor. The ultrasonic sensor is a sensor that utilizes ultrasonic waves. In the proposed system, ultrasonic sensors are used to calculate the quantity of beef based on the position of meat loaded in each rack.

Next, is the implementation of the calculation of the quantity of beef put into the meat storage rack, whether it is in accordance with the conditions of the facts of the right classification or not. With a little frequency, medium and large on each shelf. The ultrasonic sensor will calculate the quantity of meat-based on the position of the meat loaded in the rack.

C. *Implementation of Temperature Sensors*

A temperature sensor will be placed in the meat storage area. This temperature sensor will detect the temperature conditions contained in the storage rack and convert it into the form of voltages. The voltage will be forwarded to the controller to be processed into information that will be forwarded to the user's smartphone. This information is used to regulate the temperature in the meat storage rack according to its capacity so that the quality of meat is maintained properly.

D. *Output System*

Based on table 1 and table 2, the quality of beef is divided into 3, namely fresh quality, less fresh and rotten quality. When beef is input into the sensor testing box, it will give a notification in accordance with the beef consumption as in table 3.

TABLE III. SYSTEM OUTPUT NOTIFICATIONS

Beef Quality	Notification	
	Lights On	Buzzer Sounds
Fresh Quality	Green Light	No Sound
Less Fresh Quality	Yellow Light	No Sound
Rotten Quality	Red Light	Sound On

Based on table 3, if beef has fresh quality, the green LED light will light up, indicating that the beef is fresh and suitable for consumption. If beef has a less fresh quality, the yellow LED light will light up, indicating that the beef is of moderate freshness and is still suitable for consumption. If the beef has poor quality, the red LED light will light up, and the buzzer will ring, which indicates that the beef has rotten and is not suitable for consumption.

The information from the proposed system, an interface is needed that can represent that information. In this paper, all of the information is presented through an Android smartphone. In the system information on meat quality, the quantity of meat information, temperature information, and temperature control will be displayed. The data is displayed in the user's smartphone, As in Figure 4 and Figure 5.

In figure 4 shows the output display of the meat detection box, where the quality of each meat will be displayed after the detection process is done from the box. And figure 5 is a picture that shows the quantity of beef on a storage rack and the temperature of the meat storage in real-time. The temperature can be increased and reduced according to the quantity of beef in the meat storage area.

All trials and implementations have been carried out and have been running smoothly, both in terms of hardware and software as expected.

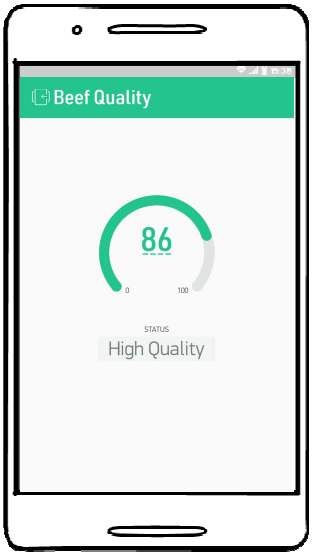

Fig. 4. Beef Quality Conditions

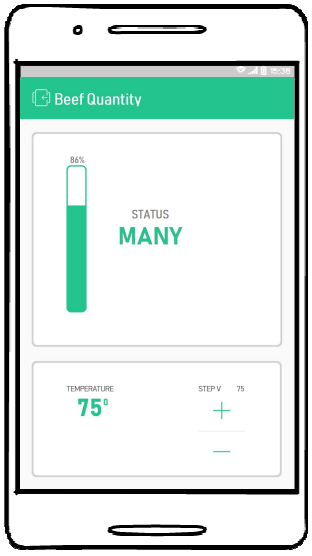

Fig. 5. Beef Quantity Conditions

IV. CONCLUSIONS

In this proposed study, it is a system to control the quality and quantity of beef in a supermarket. This system aims to replace the manual control system that has deficiencies in controlling and determining the quality of beef freshness. The proposed system is an IoT-based system that uses three gas sensors (MQ-136, MQ-137, and TGS-2602), one TCS-3200 color sensor, three LED lights, one buzzer, six HC-SR04 ultrasonic sensors, and one LM35 temperature sensor. From the results of these studies, it can be concluded that the success rate of the system proposed in determining the freshness quality of beef based on gas and color produced is 86%. For the success of the system in determining the quantity of beef on the shelves in the supermarket at 80%. So, the success of the proposed system has fairly good representation, in accordance with the theory regarding the level of freshness of beef that already exists. Thus it can be concluded that the proposed system is feasible to be used and applied to supermarkets that sell beef food products.

For further research, a box is proposed which can detect the freshness quality of various kinds of food products such as poultry meat, fish meat and other meat commonly sold in supermarkets.

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