Beef Freshness Detection Device Based on Gas and Color Sensors using the K- Nearest Neighbor Method

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Abstract

The freshness of beef becomes the most important factor affecting the quality of the meat. The need for beef continues to increase, indicating that awareness of the importance of eating meat is getting higher and higher. With the high price of beef in the market, it makes some people who cheat mix the quality of beef with cut meat that has been stored for a long time. The purchase of beef is usually carried out to identify the freshness of the meat with the naked eye and sense of smell as well as direct contact by suppressing the texture of the meat. However, this method has the disadvantage that consumers are not observant and have difficulty distinguishing the quality of beef freshness. Therefore, in this study, we tried to examine the level of freshness of beef by using the TGS 2602, MQ - 135 gas sensors as detectors of voc and ammonia compounds produced by meat and the TCS3200 color sensor by using RGB values as identification of the beef. This study also analyzed the level of beef freshness with indicators obtained from the three sensors using the K- Nearest Neighbor method. In this study, there were 3 conditions of the level of freshness of the meat tested, namely fresh meat, slightly fresh meat, and non-fresh meat with an accuracy rate of 93%.

Keywords
Sensor Tgs 2602, Senor Mq 135, Sensor Tcs 3200, ATMega328, K-Nearest Neighbor

Introduction
Beef is a livestock product as a food ingredient with high nutritional value because it is rich in protein, fat, minerals and other substances needed by the human body for growth and health. In addition, when viewed from amino acids, meat has a complete and balanced amino acid composition [1]. The need for beef continues to increase, showing awareness of the importance of eating meat is getting higher and higher so that beef is expected to have good quality and is suitable for consumption by the human body, with the high cost of beef in the market, there are some people who cheat to mix the quality of beef with cut meat that has been stored for a long time. The purchase of beef is usually identified by identifying the freshness of the meat with the naked eye and sense of smell as well as direct contact by pressing the texture of the meat and seeing the color of the meat. However, this method has the disadvantage that consumers are not observant and have difficulty distinguishing the quality of beef freshness. Therefore, it is necessary to test the quality of beef freshness before consumption.

Several studies have been conducted, among others designed a system that can identify the level of freshness of meat implemented into the Raspberry Pi by using the Neural Network as a method to perform pattern recognition at the level of freshness of the meat being tested. Another study conducted [2] designed a system that can identify the level of freshness of fish quickly. The system was implemented into Arduino uno and used K-Nearest Neighbor as a method to perform freshness recognition of the tested fish. Further research conducted [3] this tool is designed to recognize gases or scents that have a function like the human senses on the nose. The MOS Gas Sensors used in this study were TGS2600, TGS2602, TGS2620, MQ135, TGS813. By using all five MOS sensors the output of the Neural Network feed forward calculation sensor is entered into the Microcontroller.

Objectives
Based on these problems, a "Beef Freshness Detection Tool Based on Gas and Color Sensors Using the K- Nearest Neighbor Method Based on ATMega 328" was created in this study to examine the level of freshness of beef using the TGS 2602 gas sensor, MQ - 135 gas sensor as a detection of VOC and ammonia compounds produced by meat and a TCS3200 color sensor using RGB values as identification of the beef. This study also analyzed the level of beef

freshness with indicators obtained from the three sensors using the K- Nearest Neighbor method. It is hoped that this tool can help consumers to be able to find out the level of freshness of beef, such as fresh or non-fresh beef easily.

Literature Review

The most important factors affecting the freshness and quality of meat are aroma, color, texture and taste. The taste quality of the meat itself is determined by the large amount of volatile organic compound (VOC) contained in it. Meat can be classified using a tool in the same way that human perception determines quality and degree of freshness. The aroma or smell of meat is formed from the complex combination of several VOCs derived from the diverse chemical reactions that occur in the meat. Many opinions state that a fresh meat has no smell at all [4]. Some factors that can be used as a reference for choosing fresh meat include:

1. **Color**

The color of meat is one of the criteria for assessing the quality of meat that can be assessed directly. The color of meat is determined by the content and state of a meat pigment called myoglobin and is influenced by the type of animal, the age of the animal, feed, muscle activity, meat handling and chemical reactions that occur in the meat. A good fresh beef color is a bright red color. The color of freshly cut beef that has not been exposed to air is purplishred, then if it has been exposed to air for approximately 15-30 minutes it will change to a bright red color. The bright red color will change to red-brown or brown if the meat is left exposed to air for a long time.

2. **Smell**

The smell of fresh meat does not smell sour or rotten, but the characteristic smell of fresh meat. The smell of meat is influenced by the type of animal, feed, age of meat, gender, fat, length of time, and storage conditions. The smell of meat from older animals is relatively stronger than that of young animals, similarly, meat from male animals has a stronger smell than that of female animals. The rottenness of meat damage is characterized by the formation of foulsmelling compounds such as ammonia, H2S, indoles, and amines, which are the result of the breakdown of proteins by microorganisms.

3. **Texture**

Texture The fresh meat feels very chewy, dense and not stiff, if the meat is fresh when pressed the texture of the meat will return to its original appearance after pressing.

4. **Appearance**

Fresh meat is not slimy, does not feel sticky in the hands and feels wet. The rotten flesh is otherwise slimy and feels sticky in the hand. In addition, the surface of the meat is dull, dirty and there are red, black, blue, greenish-white stains due to microbial activities.

1. Methods

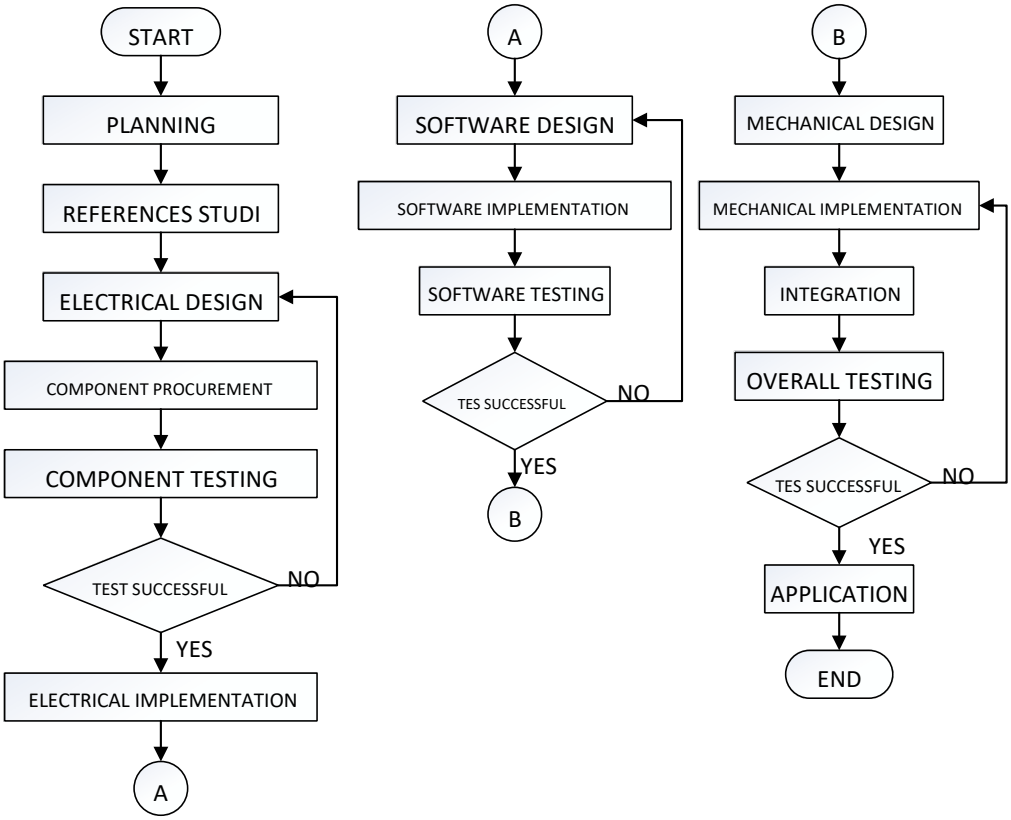

Figure 1. Research Method

Electrical Design

The electrical design stage is an illustration of how much electricity is flowed to other tools and components that require electrical power in order to run according to the design. This electronic circuit of beef freshness detection tool has several components such as LCD, Puhs button, Tgs 2602 sensor, Mq-135 sensor, Tcs 3200 which has been connected to Arduino Uno through a cable that has been connected to each Arduino Uno pin. Here's a picture of the block diagram:

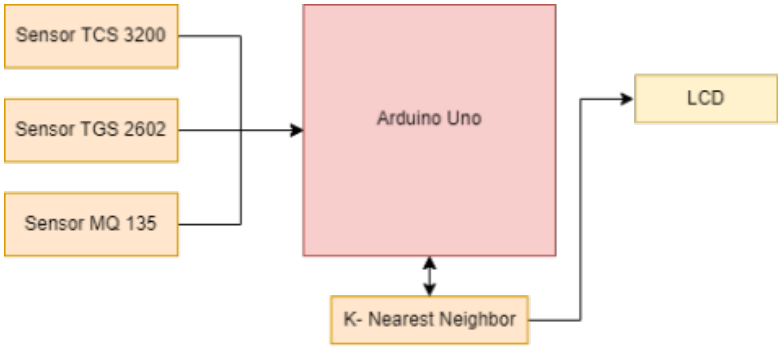

Figure 2. Block Diagram

Mechanical Design

Tool design is made in order to be able to determine the design, shape, and size of the tool which will later be adjusted to the original tool framework. Designing the appropriate tool will have an effect on the efficient performance of the

tool. The material used acrylic is in the form of a box measuring 25 cm x 15 cm x 20 cm. The selection of materials is adjusted to the needs of this research itself in order to get appropriate results but the tool remains efficient in its use.

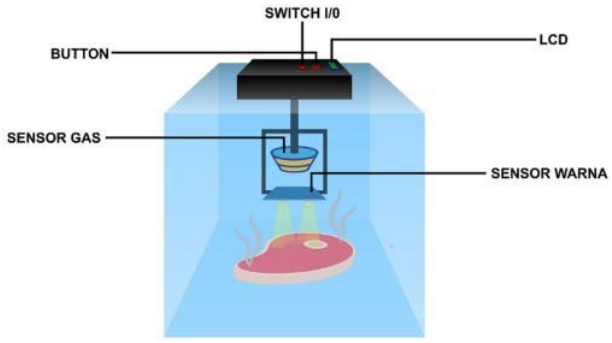

Figure 3. Mechanical Design

Simulation Model

The Simulation Model stage is a mock model of a real system, where simulation models are made such as mechanical, electrical, and software design data so that they can run more optimally and optimally.

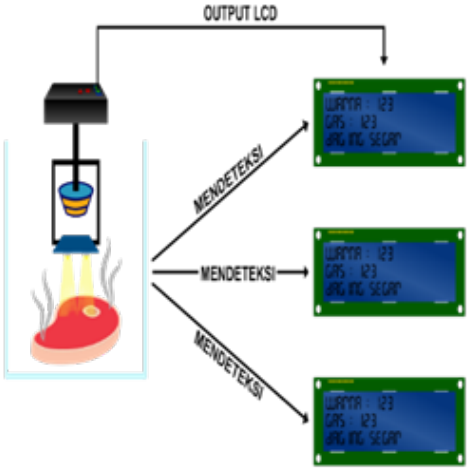

Figure 4. Simulation Model

Data Collection

Table 1. Data Collection Training

Data	TGS 2602	MQ 135	TCS 3200			Description
			R	G	B	
Data 1	5,75	17,05	23	36	42	Fresh Meat
Data 2	5,75	17,88	19	40	38	Fresh Meat
Data 3	5,8	17,01	20	38	40	Fresh Meat
Data 4	6,01	16,88	22	41	44	Fresh Meat
Data 5	6,03	16,92	22	44	38	Fresh Meat

Data 6	6,84	19,35	31	49	45	Slightly Fresh Meat
Data 7	7,14	19,55	25	50	46	Slightly Fresh Meat
Data 8	7,43	19,65	30	48	45	Slightly Fresh Meat
Data 9	6,74	19,16	31	50	44	Slightly Fresh Meat
Data 10	7,14	19,26	30	43	45	Slightly Fresh Meat
Data 11	8,92	21,11	37	54	50	Meat Is Not Fresh
Data 12	8,99	22,14	35	57	51	Meat Is Not Fresh
Data 13	8,72	21,1	35	55	50	Meat Is Not Fresh
Data 14	8,82	21,02	36	57	52	Meat Is Not Fresh
Data 15	8,92	20,98	34	52	48	Meat Is Not Fresh

The table above is the result of testing to get training data from beef that has known levels of freshness. This test was carried out with 3 categories of meat, namely fresh meat, slightly fresh meat, and non-fresh meat. In this study, the definition of the level of freshness of beef was determined through the time of storage of meat outdoors at room temperature. Definitions of the level of freshness of meat and the results of sensor testing of three meat samples with different levels of freshness are as shown in the following table.

Table 2. Limits on the degree of freshness of meat

Meat Freshness Level	Definition of Freshness
Fresh	Recently slaughtered meat/ out of the freezer
Slightly Fresh Meat	Meat that is outdoors at room temperature for ±12 hours
Meat Is Not Fresh	Meat that is outdoors at room temperature for a day or more

Results and Discussion

Numerical Results

The previous data is data that is not yet known the level of freshness of the meat, to find out the level of freshness, classification is carried out using the K-NN method. In accordance with the K- Nearest Neighbor algorithm, the first step is to determine the parameter K. In this study the parameter K is 3. Next calculate the closest distance by using the Euclidean Distance model. The calculation is as follows:

$$D = \sqrt{(aa1 - aaaa)2 + (bb1 - bbbb)2 + (cc1 - cccc)2 + (d1 - dbb)2 + (e1 - ecc)2}$$

Graphical Results

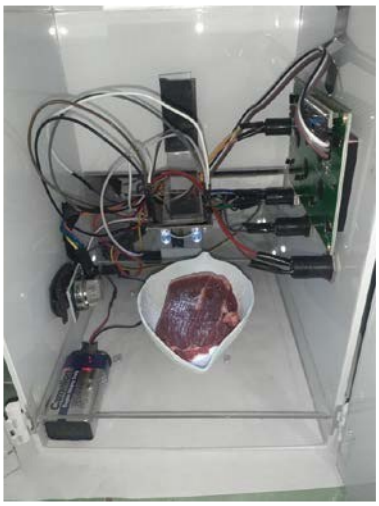

Figure 5. Appearance of meat in gas sensors

The voltage values of these two gas sensors form a pattern that presents the state of a fresh meat with a low voltage value. This is due to the condition of fresh meat that does not emit a pungent smell. When other meat samples are compared with the results of gas sensor tests on fresh meat samples, there is an increase in voltage value in both sensors. This is due to both sensor fruits responding to the aroma produced by the flesh during meat decay.

Proposed Improvements

The accuracy of testing at the level of freshness of meat can be improved by adding the amount of training data on the k- nearest neighbor, and the detection process of the level of meat freshness can use artificial intelligence methods such as Neural Network. PCA, SVM and others. In addition, it can be developed by adding texture detection sensors, using fuzzy logic and coupled with AI.

Validation

Table 3. Precision, Recall, and F1-Score

	Precision	recall	f1-score	Support
Slightly Fresh Meat	1.00	0.75	0.86	4
Fresh Meat	0.80	1.00	0.89	4
Meat Is Not Fresh	1.00	1.00	1.00	6
Accuracy			0.93	14
Marco avg	0.93	0.92	0.92	14
Weighted avg	0.94	0.93	0.93	14
		Accuracy		0,9285714285714286

From the table above, the accuracy value or score accuracy obtained is 0.9285714285714286. It can be concluded by the following accuracy values that the model performance is quite good.

Conclusion

Based on testing on the color sensor block, the color sensor can respond to differences in the level of redness that is the parameter of meat freshness. In the gas sensor test, different voltage patterns were obtained for the two sensors against 3 meat samples with different levels of freshness. Through the use of the K- Nearest method, the system built can determine the level of freshness of beef well. The more training data values and the smaller the K value, the better the accuracy of the system. The first conclusion of the system as a whole is the use of a color sensor and two gas sensors can be implemented to properly classify the level of freshness of beef. In addition, the use of human sense of smell and vision in determining the level of freshness of beef can be replaced by electronic devices in the form of gas sensors and color sensors. And the last one is that through the use of the K- Nearest Neighbor method, the system built can determine the level of freshness of beef with a success rate of up to 90%.

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Biography

Asep Denih is a Lecturer at the Computer Science Study Program, Faculty of Mathematics and Natural Sciences, Pakuan University, Bogor since 1997. The author earned his Bachelor of Computer degree in 1996 from Gunadarma University, Depok - Indonesia. Then, continued his S2 studies in the field of Information Technology for Natural Resources Management and graduated with a Master of Science degree in 2005 from IPB University, Bogor – Indonesia. After graduating from S2, the author continued his S3 studies in Environmental Informatics and graduated in 2019 from the University of Miyazaki, Japan. After graduating from Japan, the author received a mandate as Dean of FMIPA UNPAK for the 2020-2025 period. Currently, the author is the Editor in Chief at the Journal of Computing, Computer Science Study Program, FMIPA UNPAK, Bogor.

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