Journal of Data Acquisition and Processing
ISSN: 1004-9037
https://sjcjycl.cn/
DOI: 10.5281/zenodo.98549693

AN EXPERIMENTAL STUDY ON THE DEVELOPMENT OF A LOW-COST, NON-INVASIVE EQUIPMENT FOR THE QUALITY CHECK-IN PERISHABLE FOODS

Dr. Sankar P[1], Dr. Sivapriya T[*2], Dr. Maruthi R[3], Malathy S[4], Himanshu S[5]

[1]Dept of Electronics and Communication Engineering, Hindustan Institute of Technology and Science, Chennai, India.

[*2]Associate Professor, Food Technology Dept, Hindustan Institute of Technology and Science, Chennai, India.

[3]Dept of computer Applications, Hindustan Institute of Technology and Science, Chennai, India.

[4]Dept of Food technology, Hindustan Institute of Technology and Science, Chennai, India.

[5]Dept of Electronics and communication engineering, Hindustan Institute of Technology and Science, Chennai, India.

[*2]E-mail: tspriya@hindustanuniv.ac.in

ABSTRACT – *Food-borne illness is a major hazard that distresses the global economy and productivity. The most of the time, food-borne illness arises due to the consumption of spoilt or contaminated foods. This fact still remains inconspicuous to many consumers and manufacturers. Whether it is animal or plant products both get spoilt or contaminated due to certain parameters such as humidity, pH, moisture content or poor handling etc. This in turn has led to huge consequences amongst the population who consumes the same. Thus, the standards and requirements of the food have to be put under strict surveillance. Perhaps there are several methods available like DNA-based and omics based, but are considered to be highly invasive methods. Since sensor technology and IoT are growing at a rapid stage. Food safety methods can be improved by creating gadgets and equipment in a non-invasive way. In this paper an attempt has been made to design an IoT based equipment for measuring the spoilage of foods. In addition to it an analysis has been made to see the performance efficacy of the same.*

Keywords: *Food spoilage, quality control, Arduino uno, Gas sensor, Ph sensor, wi-fi*

I. Introduction

The burden of food-borne illness is usually under-reported and it causes a menace in the lives of human beings (Scallan et al., 2011). Every year, 600 million people throughout the world get sick from consuming tainted food (Scallan et al., 2011). Food borne diseases hinders productivity by straining health care systems and diluting the nation's economy (Scallan et al., 2011). As by quote, "Prevention is better than cure", food borne illness can be reduced considerably by ingesting quality foods. This quality can be monitored by using sensors.

Sensors are devices designed to help in detecting the spoilt food in advance (Faradilla et al., 2018). These are analytical devices that combine with a biological component and detect the essential parameter. It in turn helps to reduce the burden of food poisoning and food-borne illness. The pH indicator involved in it directly signals the quality of the product. The indicators in place help to identify the presence of the first type of alteration, such as pH, gas composition, etc. They then translate it into a reaction that is simple to gauge and associate with the freshness of the food. This response can be influenced by changes to molecules that affect the metabolism of microorganisms, such as the presence of amines, glucose, or compounds containing sulphide, volatile nitrogen compounds, carbon dioxide, ethanol, organic acids, etc. during storage. This helps us to identify the presence of microbial growth. This type of indicator relies either on the direct detection of metabolites by biosensors or the indirect detection of metabolites using colour indicators (such as pH) (Faradilla et al., 2018). Hence researchers started developing and introduce truffle board to cold stockpiles. These truffle boards identify the meteorological conditions that raise or speed up the rot of the food, the meteorological circumstances going to be overseen by refrigeration and void stockpiles. An embellishment is set up to monitor the food grains and to maintain the storage system at home. An advanced board, such as the Renesas GR Peach, has been suggested by the authors in this study, and it has been employed as a central processing unit with various sensors implanted to build a smart home food, grain storage maintenance, and well-defined monitoring system (Shariff etal., 2018).

There is a growing interest among scientists who have come up with various norms related to the supervision and detection on the quality of food. Mary et al., 2021, have proposed a system to monitor the changes observed in the chemical composition of the food. This in turn alerts the change in the quality of food based on electrical and biosensor’s signals.

When we consider marine products the probability of spoilage is higher as compared to other generic food that we consume. Methyl Red (MR) and Bromo Cresol Purple (BCP) are commonly used as pH indicator to detect the freshness of the same. As the marine products begins its process of spoilage, the pH indicators mentioned formerly starts to change its color where by MR changes from red to yellow, while the BCP changes from yellow to purple based on the pH. Another indicator that can be used is none other than label. The label is a simple and reliable quality indicator for monitoring and detecting the quality of packaged foods continuously by data capturing and collection by cloud computing and the IoT.

Shahzad et al., 2018 in their studies has cited that objective methods of checking food items by eyes, nose, and taste buds are time consuming, expensive and sometimes not precise due to human errors and environmental effects. In order to create a smart food freshness detector that ensures food freshness and tells us whether to eat it or toss it, it is necessary to identify and choose precise sensors to measure pH, moisture, and gas values.

II. Proposed methodology

The goal of this technology is to create an electronic device with sensors built in that can recognize food rotting. In this venture, an effective communication has been carried out with different sensors for example MQ3, MQ2, MQ135, pH sensor, DHT 11 sensor with Arduino to screen the ecological circumstances. Here, the sensors can assess a variety of dietary characteristics, including pH, moisture, and ethanol content. The server receives the data that the sensor has collected. The client can connect to the server through a webpage that can periodically be refreshed to retrieve the parameters' quality and, consequently, the state of the food. To prevent unauthorised access to the data set, a login page is used. The framework may be used to monitor the various stock room limits. In addition, it will provide illumination by sending data to a distributed computing server and leveraging IoT.

Food Freshness Detector is an application that assists in deciding pH level utilizing a pH sensor. The architectural framework is displayed in Figure 1. This framework includes a pH sensor, humidity sensor, temperature sensor, and pressure sensor. The microcontroller, which is key to the application, receives input from the pH sensors, transmits the information to a dedicated LED, and ultimately generates the output. The proposed framework's main objective is to provide an IoT-based distribution centre observing framework. The cloud-based architecture is suggested to enhance the features. A number of sensors are attached to the framework. The framework is divided into two parts: a web management system and a sensor subsystem.

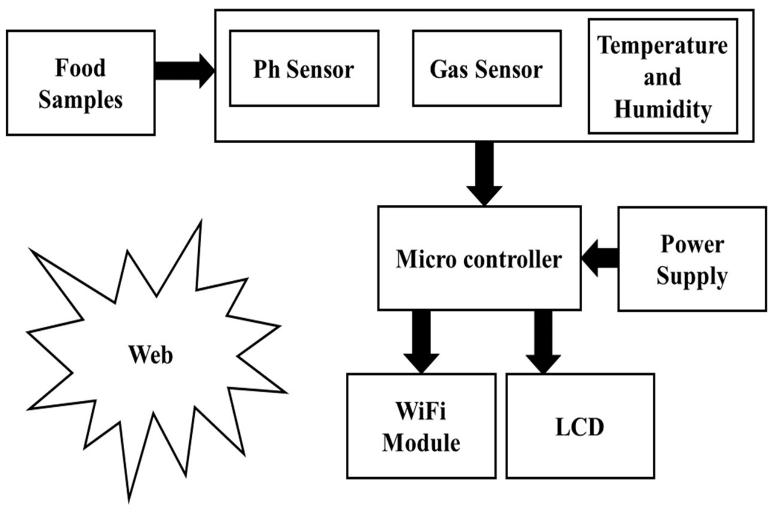

Fig 1: Architectural framework

Sensor Subsystem:

The sensor network includes three sensors: DHT 11 sensor, MQ sensor and PH sensor. The DHT11 estimates both moistness and temperature. It has an innovative temperature and stickiness sensor that is basic and extremely inexpensive. It measures the surrounding air using a capacitive moisture sensor and a thermistor, and it emits an advanced signal on the information pin using the stickiness detecting component and thermistor. It will constantly screen the temperature and dampness conditions where the food is put away. The dampness detecting part has two anodes with dampness holding substrate between them. The opposition between the anodes changes as there is variety in the moistness. Also, for the temperature, the thermistor is utilized which is a variable resistor whose esteem fundamentally shifts with the adjustment of temperature. The MQ 3 sensor recognizes the nitrogenous gases which come from the food when it is rotten. The conductivity of the touchy material present in the MQ 3is lower in clean air. As the centralization of ethanol gases expands, its conductivity increments. At the point when the objective dangerous gases exist, the sensor's conductivity builds increasingly more with the expansion in the centralization of the gases. The MQ-2 Gas-sensor can detect or identify gases such as methane, hydrogen, LPG, propane, and even alcohol. When using this sensor in its module form, which has a Digital Pin, it may function without a microcontroller, which is useful when trying to recall on a certain gas. Use a simple pin to calculate the gas's concentration in ppm. The MQ-135 Gas sensors are utilized in air quality control equipment and are appropriate for NH3, benzene, smoke, NOx, alcohol, and CO2 perception or assessment. The MQ-135 sensor module has a digital pin, allowing it to communicate with a microcontroller.

Web administration:

A web URL is allotted to the client to get to the dashboard. One can utilize the assistance either on a mobile phone or a PC. A webserver is a program that handles client requests from an organisation and provides them with the information that creates its pages. Hypertext Transfer Protocol is used for this transaction. Essentially, webservers are PCs used to store HTTP documents which make a site and when a client demands a specific site, it conveys the mentioned site to the client. Presently, the PC will send a HTTP solicitation to see the Facebook page to one or more PC known as the web-server. This PC (webserver) contains every one of the documents (for the most part in HTTP design) which make up the site like text, pictures, gif records, and so forth. Subsequent to handling the solicitation, the webserver will send the mentioned site related documents to the PC and afterward you can arrive at the site. Using Arduino programming, the microcontroller was modified. It has been decided that the pH sensor's pointer range for this application will be from 0.00 to 14.0. Due of the sensor's limited ability to cook decimal places; any minor pH value variations can be recognized. The framework is put into action by including all the necessary components and connecting them using Arduino programming. A crude meat newness level using a pH sensor has been constructed and tested on a small amount of meat test bought from the local market. Test has additionally been directed on sensor capacity responding with a few cushion arrangements on meat tests left at room temperature at different time frames. By and large, the inserted pH sensor created has effectively tried crude meat newness level in view of meat sharpness level. Data are shipped off the server the client can get refreshes connected with food through Webpage. For safe access to the data set, the webpage was used. The system helps to monitor the various stockroom perimeters and will also provide illumination by transmitting data via IoT to a distributed computing server.

pH value measurement

The pH value of food has a direct impact on microbial development and, hence food quality and safety. As a result, many companies utilize pH value as a quality criterion when evaluating their products. In the production of meat, sausage, delicatessen, and dairy goods, the pH value is critical. In the food industry, the pH value is a critical quality indicator. It significantly affects the color, flavor, softness, and shelf life of meat and meat-based products in addition to their ability to bind water. Even sour dough in the bakery sector can have its acidity assessed using the pH value. The pH value aids in the production of items such as salad dressings which helps to identify the consistency of acidity thereby the quality.

Temperature and Humidity measurement

The food moves from the producer to the consumer, after travelling longer distances. Customers demand consistently fresh and high-quality goods, whether they are deep-frozen food or farm-produced goods like fish, meat, vegetables, dairy, or coffee. One should rely on the continual temperature and humidity monitoring and documentation in the transportation of meat to ensure it.

III EXPERIMENTAL SETUP

In this section the experimental setup, design, and implementation details are presented. The specification of the setup was to monitor the temperature, humidity, smell and pH values of the food which it might be subjected to. It consists of an AT Mega 328 microcontroller which is interfaced with ESP 8266 WIFI module. The microcontroller was connected with several sensors such as MQ2 and MQ135 gas sensors to determine the foul smell coming out of the food product. The controller was interfaced with a DHT11 sensor to determine environmental factors like temperature and humidity.

To interact with the IOT it was the technology that connects the digital world by transforming the UI interaction between humans and machines. Login access need to be given with a user name and password and from there the required data can be monitored. Several types of perishable food items have been collected and tested to see the effectiveness of the designed machine.

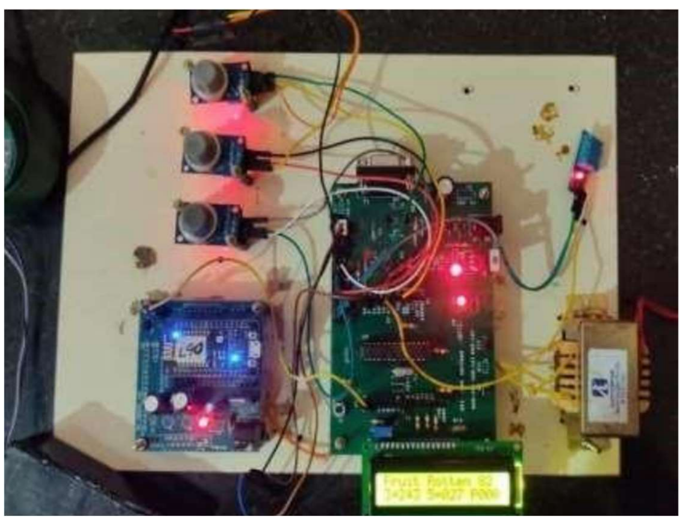

Fig. 2: Experimental setup for the measurement of sensors

IV. RESULTS AND DISCUSSION

The meat business and consumers place a high value on meat quality. The need for high-quality protein is growing along with the need for nutritious food, meat and its protein, which is essential components of the human diet, can be used to complement this demand (Panea and Ripoll, 2018). Meat that is of high grade often has a pH between 5.7 and 6.0. The parameters of meat quality will be influenced by the rate and magnitude of the post-mortem pH decline. The term "meat quality" refers to a collection of qualities including color, tenderness, water-holding capacity, taste, pH, and shelf life, all of which are impacted by genetic and ecological variables. (Zmudzińska et al., 2020)

Muscle tissue has a neutral pH range of 7.0 to 7.2 when an animal is alive, but before and during slaughter, muscles start to change into meat. Once anaerobic glycolysis reaches a maximum and the Cori cycle starts, the oxidation process stops and anaerobic glycolysis increases. The production of lactic acid during the Cori cycle hastens the acidification of muscle tissue, which can be measured by the pH value (Erin and Boler, 2019).

Meat quality and its classification into Pale, Soft, Exudative (PSE) normal, and Dark, Fresh, Dry (DFD) kinds are predicted using the pH values of meat 45 minutes after slaughter. Meat's pH values, measured 45 minutes after slaughter, fall into three categories: lower than 5.8, semi-PSE meat with values between 5.8 and 6.0, and normal meat with values above 6.0. The majority of researchers use the limits of pH readings as a classification system for meat. The process of spoiling begins once pH falls below the optimal range (5.8 to 6.2 for pork), causing the flesh to become whiter, softer, and more prone to drip loss. (Kasprzyk and Bogucka, 2020; Cebulska et al., 2020)

The Arduino-based gas sensors had the option to detect the deterioration like the awful stench from the food. The degree of discharged gas can be associated with how much food is spoilt. The framework which incorporates implanted framework alongside sensors are delicate to detect low productions of the gases like ammonia and methane because of the deterioration of the food. The degree of gases discharged will fluctuate depending upon the decay of the food.

The gas sensor may identify gas emissions from food items even before there are any outward signs of spoiling, thanks to the early detection of gases from various food items, such as methane, ammonia, etc. The consumer gets the information about the food item wherein one can monitor the perishability of that food item. This will help in the maintenance of health and prevents the consumer from consuming spoilt food. Some of the standards specified by researchers are shown in Table 1 to Table 4 (Jay, J. M et al).

Fresh and rotten products are collected from several market vendors (Koyambedu market area in Chennai) to check the pH value at certain degrees of temperature. This was used to test the efficacy of the machine performance. The Table-1 shows the range of pH values of the different meat products obtained from the Koyambedu market.

Table 1- The range of Meat products in the market

SNo	Meat products	Range of pH values	Temperature
1	Beef	5,1-6.2	28^0C
2	Ham	5.9-6.1	27^0C
3	Veal	6.0	27^0C
4	Chicken	6.2-6.4	29^0C
5	Fish	6.6-6.8	30^0C
6	Shrimp	6.8-7.0	27^0C
7	Clams	6.5	30^0C

8	Crabs	7.0	27^0C

All products mentioned in the table need not be available always. Some of them may be available, but it is in refrigerated condition only. If refrigerated, one should ensure that the meat products are not spoiled. The different kinds of fruits in the market are shown in Table 2. Most of them are acidic in nature. When these fruits are used to extract the juices and if its pH value is measured then it can see that these lies midway between this ranges. As compared with the meat products the pH value is comparatively lesser and the chances of getting spoiled are low.

Easily perishable ones are the milk products in the market. The temperature varies above 30° C the chances of spoilage is very high even though the milk products pH values are below 7.

Table 2- Different kinds of fruits in the market

SNo	Fruits	Range of pH values	Temperature
1	Apples	2.9-3.4	28^0C
2	Lemon	1.8-2.0	27^0C
3	Grapes	3.4-4.5	27^0C
4	Banana	4.5-4.7	29^0C
5	Pineapple	3.20-4.0	30^0C

Table 3- Various types of Milk products

SNo	Milk Products	Range of pH values	Temperature
1	Milk	6.3-6.5	28^0C
2	Butter	6.1-6.4	27^0C
3	Yoghurt	4.6-5.0	27^0C
4	Fresh Cream	6.5	29^0C

Table 4- Variety of Vegetables obtained from the market

SNo	Vegetables	Range of pH values	Temperature
1	Carrots	4.3-6.9	28^0C
2	Beans	6.0-7.5	27^0C
3	Potatoes	5.6-6.2	27^0C
4	Cabbage	5.4-6.3	29^0C
5	Tomatoes	3.4-4.9	30^0C

Variety of vegetables are obtained from the market, from which most commonly used ones are collected and it is shown in Table 4. These vegetables will not perish so quickly even though the temperature has gone above 30ºC.

In-order to carry out the experiments in the setup, most of the products was collected from the market in two categories and tested its pH values at different temperature. The first category comprises of good products and the second categories were selected which are perished ones. This has been extensively tested using the designed machine to calculate the pH value at various temperatures. The intensity of freshness and spoilage were found out from the food collected and they are given in Figure 3 and Figure 4.

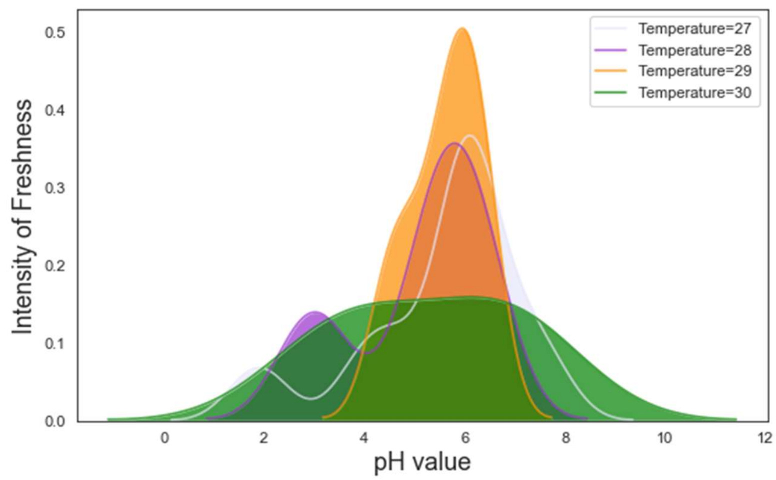

Fig 3: The variations of Freshness of food at various Temperatures

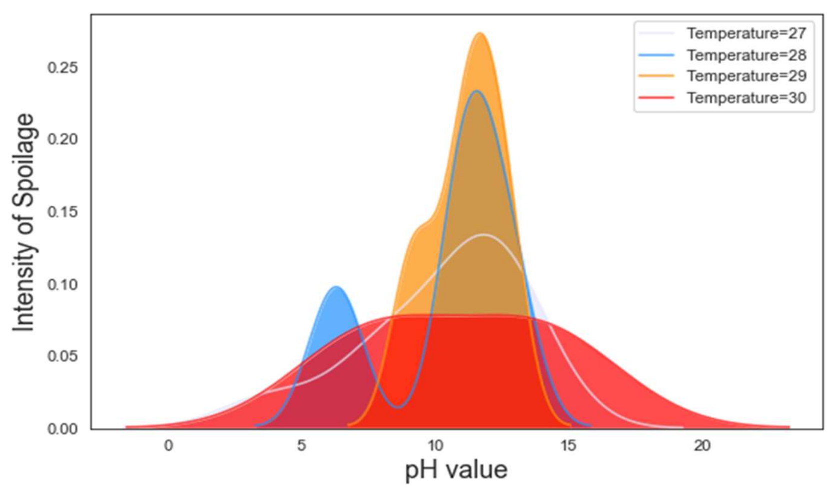

Fig 4: The variations of Spoilage of food at various Temperatures

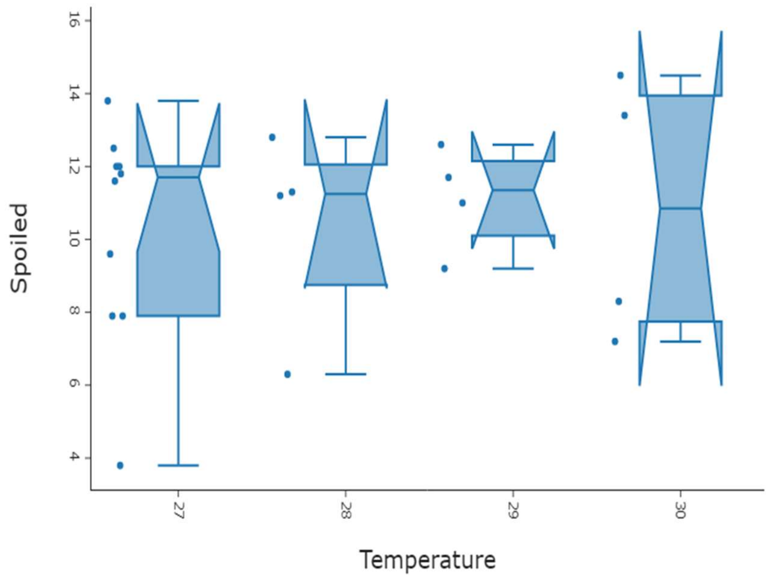

Fig 5: The Spoiled Foods at each Temperature

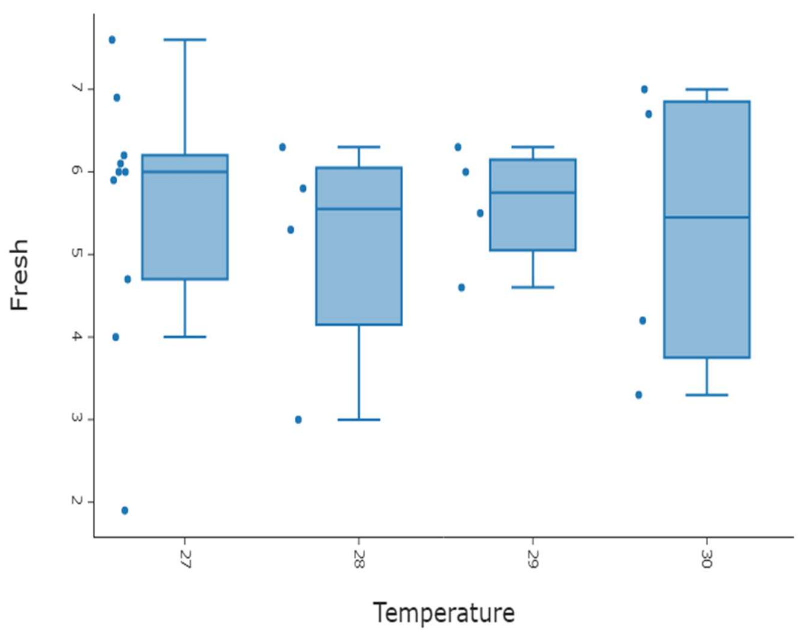

Fig 6: The Fresh Foods at each Temperature

The Figures 5 and 6 give the fresh and spoiled foods obtained at various temperatures. In Figure 5 the dots indicate the spoiled food at various temperatures irrespective of the category. The notch diagrams seen in the figure gives the min, max, median and the quartile range (q1 &q3) for each set of values in the database. Taking the smallest notched box gives the values as 9.2, 12.6, 11.35, q1 being 10.1 and q3 being 12.15. Similarly, from Figure 6 the dots indicate the fresh food at various temperatures. Considering the smallest box gives the values as 4.6, 6.3, 3,75, q1 being 5.05 and q3 being 5.15 respectively.

IV. Conclusion

Meat is one of the most perishable commodities due to its moderate pH, high nutrient and moisture content. The pH value of fresh meat is between 5.8 – 6.2. At present, consumers rely only on the expiry date of the meat in packages to know about the quality however this information does not always portray the actual progress of food spoilage.

The information required for food safety is efficiently collected and communicated in this article using a variety of sensors. Arduino uses a variety of sensors, including MQ, pH sensors, and DHT11 sensors. Through a webpage, information transmitted from the server to the client can periodically be refreshed. A website page was used to ensure secure access to the data base. By sending the data on the distributed computing server through IoT, the framework may be used to monitor the various stockroom borders.

In future the proposed gadget can be improved by applying Artificial Intelligence to distinguish the early deterioration of food products. This can be used in refrigeration frameworks for identifying different types of food and check for the avoidance of contamination or deterioration. The gadget can be integrated into food transportation holders which would permit and easily distinguish the decay if any, during transportation. The gadget could likewise be tried for various assortments of food sources.

References

- Wan Elina Faradilla, Wan Khalid, Nur IzzatulAfiqahJais, et al. (2021) A mini review on sensor and biosensor for food freshness detection", Malaysian Journal of Analytical Sciences, Vol 25 No 1 (2021): 153 - 164
- Saleem Ulla Shariff, M.G. Gurubasavanna, C.R. Byrareddy. (2019) IoT-Based Smart Food Storage Monitoring and Safety System", International Conference on Computer Networks and Communication Technologies, 2019 pp 623-638.
- Scallan E, Hoekstra RM, Angulo FJ, Tauxe RV, Widdowson MA, Roy SL, et al. (January 2011). "Foodborne illness acquired in the United States--major pathogens". *Emerging Infectious Diseases*. **17** (1): 7–15. doi:10.3201/eid1701.P11101
- Milintha Mary T P. (2021) Development Of Biosensor for Fish Products (Mackerel, Sardine, Pomfret, Red Snapper, Cuttle Fish And Shrimp), Spast Abstracts: Vol. 1 No. 01: Smart Green Connected Societies
- Naveed Shahzad, Usman Khalid, Atif Iqbal, Meezan-Ur-Rahman. (2018) EFresh – a Device to Detect Food Freshness. International Journal of Soft Computing and Engineering (IJSCE) ISSN: 2231-2307, Volume-8 Issue-3.
- Sipiwe Chihana, Jackson Phiri, Douglas Kunda. (2018) "An IoT based Warehouse Intrusion Detection (EPerimeter) and Grain Tracking Model for Food Reserve Agency", International Journal of Advanced Computer Science and Applications, Vol.9, No.9,2018
- Panea B, Ripoll G (2018) Quality and safety of meat products. Foods 7:118. https://doi.org/10.3390/foods7080118

- Zmudzińska A, Bigorowski B, Banaszak M, Roślewska A, Adamski M, Hejdysz M (2020) The effect of diet based on legume seeds European Food Research and Technology (2021) 247:2813–2820 2819 1 3 and rapeseed meal on pig performance and meat quality. Animals 10:1084. https://doi.org/10.3390/ani10061084
- Erin BE, Boler DD (2019) Factors to consider in regards to pork quality. Des Moines, pp 1–12
- Kasprzyk A, Bogucka J (2020) Meat quality of Pulawska breed pigs and image of longissimus lumborum muscle microstructure compared to commercial DanBred and Naima hybrids. Arch Anim Breed 63:293–301. https://doi.org/10.5194/aab-63-293-2020
- Cebulska A, Václavková E, Bocian M, Dybała J, Wiśniewska J, Kapelański W (2018) Quality and dietary value of pork meat of the puławska and złotnicka spotted breeds, and commercial fattening pigs. Ann Anim Sci 18:281–291. https://doi.org/10.1515/aoas-2017-0033
- Jay, J. M. Modern Food Microbiology, 6th ed.; Aspen Publishers: Gaithersburg, Maryland, 2000. [30] Lund, B.; Baird-Parker, A. C.; Baird-Parker, T. C.; Gould, G. W.; Gould, G. W. Microbiological Safety and Quality of Food; Aspen Publishers, 2000.