Design of Squid Quality Classification Device using Electronic Nose Technology

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Abstract— **The evaluation of the quality of squid is a crucial procedure in the seafood industry, and the analysis of odor has become a potential technique for determining the level of freshness. However, the traditional approach to evaluate the quality of squid is manually classified and sorted based on odor which could result in health effects ranging from none to mild discomfort, to more serious symptoms. The project aims to solve the problem by designing a device that can classify the quality of squid, distinguish between fresh and non-fresh and sort them following the engineering standards and considering various constraints. The device utilizes a Metal Oxide Semiconductor Sensor connected to the Arduino to detect the odor of squid, while the servo motor was employed to sort the squid based on their quality. The test can be concluded that the design of an electronic nose technology that can classify the squid quality has achieved all of its objectives. The project was validated by experts with an accuracy of 98.75%. Therefore, the device provides a valuable solution that helps squid dealers in precisely categorizing the quality of squid.**

Keywords— Squid, Odor, Sensor, Quality, Electronic Nose Technology

I. INTRODUCTION

Squids were among the important commercial fish landed in the Philippines. Landings of squid have been recorded since the start of the Philippine Fisheries Statistics in 1940. In 2020, squid production was recorded to be 37,216 metric tons, and about 4,595,532 values in peso [1]. Freshness is an important quality of squid with respect to determining the market price [2].

Currently, seafoods, especially squids, are highly perishable due to the influence of many post-mortem factors, so their loss of quality (safety, nutritional, and sensory properties) is very rapid [3]. Improper food handling contains harmful bacteria, viruses, parasites, or chemical substances that cause more than 200 diseases, ranging from diarrhea to cancers [4]. Thus, getting the right quality of local squid is essential for the squid industry and fisheries. Humidity, temperature, and odor are one of the critical parameters to verify in many fields of food industry processes, from assurance of quality during production up to storage and transport to final users [5].

One indicator of the quality of seafood based on SNI 01-2720.1-2006 is odor, which in spoiled seafood produces a very strong smell. This unpleasant odor is generally composed of hydrogen sulfide [6]. As sulfur-containing amino acids break down, they release unpleasant smells that eventually transform into hydrogen sulfide gas [7]. Certain foods like lean meat, seafood, eggs, which contain high levels of sulfur-containing amino acids, can produce hydrogen sulfide due to the presence of microorganisms [8].

However, one of the usual methods for classifying the squid's quality is done by manual smelling [9]. Exposure to odors could result in health effects ranging from none to mild discomfort, to more serious symptoms. Strong odors may cause some people to feel a burning sensation that leads to coughing, wheezing or other breathing problems [10]. Therefore, there is a need to design a device that would classify the squid quality using electronic nose technology.

II. OBJECTIVES

The main objective of this project is to create an electronic nose for squid that can classify the quality according to the needs of the client in compliance with engineering standards and with consideration of constraints including economic, safety, sustainability, risk, environmental, public health, welfare, social, global, and cultural along with computation of trade-offs from selected constraints.

Specific Objectives:

● To design a prototype that detects the hydrogen sulfide of the squid and classify as fresh and non-fresh.
● To design a prototype that sorts and counts the fresh squid and non-fresh squid and displays the number of fresh and non-fresh.
● To test and evaluate the accuracy of the system.

III. METHODOLOGY

This chapter discusses the hardware design of the project that considers the project objectives discussed in the second chapter.

Hardware Design

Hardware design refers to the process of creating and developing the physical components, circuits, and systems of a computer or electronic device. It involves designing the architecture, selecting and integrating components, creating schematics and layouts, and ensuring functionality, reliability, and performance of the hardware. The 3D model is created using Autodesk Fusion360 software.
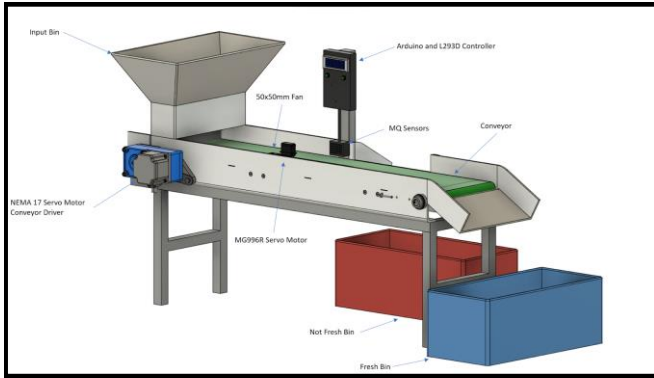

Fig. 1. Overall Hardware Design

Figure 1 shows the final design of the automated squid quality classification and sorting. From the right is the input bin made up of stainless steel that will hold the stock of squid, then it will feed on the belt type conveyor that is driven by a 12V DC motor. Once the squid reaches below the camera and the MQ sensors , the conveyor will suddenly stop 2-3 seconds for the squid appearance to be properly obtained by the camera and odor classification. A fan is used to help the flow of odor towards the electronic nose, which ensures that the air carrying odor molecules reaches the electronic nose consistently. If no hydrogen sulfide was detected in the squid it means that it is fresh, the conveyor belt will start running and transport the squid to fresh bin.

Otherwise, if hydrogen sulfide was detected starting at 1 ppm it indicates that it is non-fresh, the conveyor belt will also start running and triggers the servo motor to push non fresh squid and put it to non-fresh bin. Lastly, if the camera detects any object other than squid, the servo motor will trigger to push it to bin 2. The whole system can also be "start and stop" using the push button on the controller box.
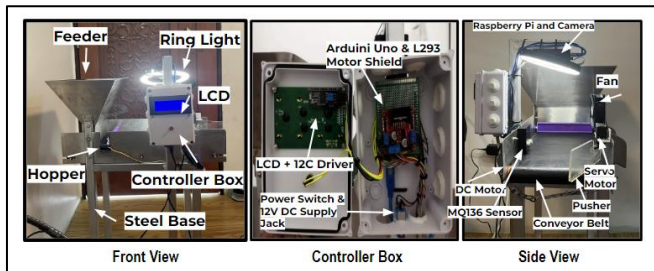

Fig. 2. Front, side-view and controller box of the prototype

Figure 2 shows the Front, side-view and controller box of the squid quality classification and sorting device. On the left side was a feeder constructed with aluminium steel, serving as the storage for squid stock. The squid would then be transferred onto a belt-type conveyor, propelled by a 12V DC motor. Upon reaching the area beneath the raspberry pi, camera, and electronic nose technology (MQ136 Sensor), the conveyor would abruptly halt for a brief duration, allowing the camera to capture the squid's appearance and conduct odor classification. The fan is employed to facilitate the movement of odor towards the electronic nose, guaranteeing a consistent and continuous supply of air containing odor molecules to the electronic nose. Detection of low to none ppm level of hydrogen sulfide in the squid indicated its freshness. In such cases, the conveyor belt would commence operation, transporting the squid to bin one (1). Conversely, if high levels of hydrogen sulfide were detected, it indicates that the squid was non-fresh.

As a result, the conveyor belt would initiate movement and activate the servo motor to push the non-fresh squid into bin two (2). Furthermore, if the camera detected any object other than squid, the servo motor would activate, relocating the object to bin two (2). The device includes an LCD screen that shows detailed input information and detects and counts fresh and non-fresh squids using the camera and odor sensors. The entire system could be initiated or halted using the power switch button situated on the controller box.

IV. TESTING AND RESULTS

The test and evaluation results consist of data and information obtained from various tests conducted, which depend on the design's test procedures and scenarios. Testing methods used were described, and the resulting data was organized into a table. This table summarizes the results of each test, including relevant remarks

To be considered accurate, the average percentage accuracy must be greater than or equal to 95%, as required by the Standard for Accuracy of Measuring Devices. The percentage (%) accuracy formula calculates how accurate the application's results are. The following is the formula for calculating the percentage and average accuracy:

$$Percentage\ Accuracy = 100 - \left|\frac{Expected\ Output - Actual\ Value}{Expected\ Output}\right| \times 100$$

Where:

Expected Output = Output acquired from the Hydrogen Sulfide Tester
Actual Output = Output acquired by the Prototype (SquidTech)

$$Average\ Accuracy = \frac{Sum\ of\ the\ values\ of\ the\ trials}{Number\ of\ each\ trials}$$

Where:

Sum of the values of the trials = Sum of all the expected values from the trials
Number of each trials = Total Number of trials

A. Case 1: Test for Detecting Hydrogen Sulfide

In this case, the input consists of fresh and non-fresh squid to determine if the device can identify them as fresh squid or non-fresh squid.

TABLE I.   SUMMARY OF ACCURACY TESTING FOR CASE 1

Trials	Input	Expected Output (Hydrogen Sulfide Tester Output)	Actual Output (Prototype Output)	Interpretation (Fresh = 0 ppm Non-Fresh = 1-20 ppm)	Remarks
1	Squid	2 ppm	2 ppm	Non-Fresh	Accurate
2	Squid	2 ppm	2 ppm	Non-Fresh	Accurate
3	Squid	0 ppm	0 ppm	Fresh	Accurate
4	Squid	3 ppm	3 ppm	Non-Fresh	Accurate
5	Squid	3 ppm	3 ppm	Non-Fresh	Accurate
6	Squid	0 ppm	0 ppm	Fresh	Accurate
7	Squid	2 ppm	2 ppm	Non-Fresh	Accurate
8	Squid	0 ppm	1 ppm	Non-Fresh	Inaccurate
9	Squid	3 ppm	3 ppm	Non-Fresh	Accurate
10	Squid	3 ppm	3 ppm	Non-Fresh	Accurate
11	Squid	4 ppm	4 ppm	Non-Fresh	Accurate
12	Squid	0 ppm	0 ppm	Fresh	Accurate
13	Squid	0 ppm	0 ppm	Fresh	Accurate
14	Squid	0 ppm	0 ppm	Fresh	Accurate
15	Squid	0 ppm	0 ppm	Fresh	Accurate
16	Squid	2 ppm	2 ppm	Non-Fresh	Accurate
17	Squid	0 ppm	0 ppm	Fresh	Accurate
18	Squid	4 ppm	4 ppm	Non-Fresh	Accurate
19	Squid	3 ppm	3 ppm	Non-Fresh	Accurate
20	Squid	0 ppm	0 ppm	Fresh	Accurate
21	Squid	3 ppm	3 ppm	Non-Fresh	Accurate
22	Squid	3 ppm	3 ppm	Non-Fresh	Accurate
23	Squid	0 ppm	0 ppm	Fresh	Accurate
24	Squid	3 ppm	3 ppm	Non-Fresh	Accurate
25	Squid	0 ppm	0 ppm	Fresh	Accurate
26	Squid	0 ppm	0 ppm	Fresh	Accurate
27	Squid	5 ppm	5 ppm	Non-Fresh	Accurate
28	Squid	4 ppm	4 ppm	Non-Fresh	Accurate
29	Squid	0 ppm	0 ppm	Fresh	Accurate
30	Squid	2 ppm	2 ppm	Non-Fresh	Accurate
	Average	29/30 (96.67%)			Accurate

Table 1 contains the summary of accuracy testing for detecting hydrogen sulfide level. One of the objectives of this system is to design a prototype that can classify the quality of squid based on hydrogen sulfide. The test for detecting hydrogen sulfide has achieved an accuracy result of 29 out of 30 (96.67%). This accuracy level meets the standards set by the ISO 5725-1:1994. According to OSHA guidelines, an odor threshold of 0.01-1.5 ppm, when a rotten egg smell first becomes noticeable, indicates a significant presence of hydrogen sulfide. Therefore, when the device registers a reading of 1 part-per-million (ppm), it confirms the deterioration and lack of freshness in the squid being tested. These results highlight the efficacy of the hydrogen sulfide detection test in accurately identifying the spoilage levels in food products.

B. Case 2: Test for Validation of Non-Squid Objects

In this case, the input comprises non-squid objects to validate if the device can identify it as a squid or not squid.

TABLE II.   SUMMARY OF ACCURACY TESTING FOR CASE 2

Trials	Input	Expected Output	Actual Output	Remarks
1	Shrimp	Not squid	Not squid detected	Accurate
2	Shrimp	Not squid	Not squid detected	Accurate
3	Shrimp	Not squid	Not squid detected	Accurate
4	Shrimp	Not squid	Not squid detected	Accurate
5	Shrimp	Not squid	Not squid detected	Accurate
6	Shrimp	Not squid	Not squid detected	Accurate
7	Scissor	Not squid	Not squid detected	Accurate
8	Onion	Not squid	Not squid detected	Accurate
9	Calamansi	Not squid	Not squid detected	Accurate
10	Glue	Not squid	Not squid detected	Accurate
11	Perfume	Not squid	Not squid detected	Accurate
12	Hair Clip	Not squid	Not squid detected	Accurate
13	Tomato	Not squid	Not detected	Inaccurate
14	Calamansi	Not squid	Not squid detected	Accurate
15	Calamansi	Not squid	Not squid detected	Accurate
16	Hair Clip	Not squid	Not squid detected	Accurate
17	Perfume	Not squid	Not squid detected	Accurate
18	Perfume	Not squid	Not squid detected	Accurate
19	Pliers	Not squid	Not squid detected	Accurate
20	Mouse	Not squid	Not squid detected	Accurate
21	Mouse	Not	Not squid	Accurate

		squid	detected	
22	Garlic	Not squid	Not squid detected	Accurate
23	Garlic	Not squid	Not squid detected	Accurate
24	Avocado	Not squid	Not squid detected	Accurate
25	Avocado	Not squid	Not squid detected	Accurate
26	Avocado	Not squid	Not squid detected	Accurate
27	Onion	Not squid	Not squid detected	Accurate
28	Mouse	Not squid	Not squid detected	Accurate
29	Calamansi	Not squid	Not squid detected	Accurate
30	Onion	Not squid	Not squid detected	Accurate
	Average	29/30(96.67%)		Accurate

Table 2 shows the summary of accuracy testing for validation of non-squid objects. Since the device focuses only on classifying squid, the system utilizes error-handling detection to identify which objects are passing through it. As a result, the testing for non-squid objects revealed an impressive average of 96.67%, indicating a high level of accuracy in identifying and classifying these objects. This accuracy level meets the standards set by the ISO 5725-1:1994. However, the tomato was not detected by the system and this caused it to become inaccurate.

C. Case 3: Test for Displaying the Count of Classified Squid

In this case, the input comprises the classification process and capturing image to determine if the detected squid are counted and displayed in the LCD.

TABLE III.   SUMMARY OF ACCURACY TESTING FOR CASE 3

Trials	Device	Expected Output	Actual Output	Remarks
1	Increment After Classifying Fresh Squid	1	1	Accurate
2	Increment After Classifying Fresh Squid	2	2	Accurate
3	Increment After Classifying Fresh Squid	3	3	Accurate
4	Increment After Classifying Fresh Squid	4	4	Accurate
5	Increment After Classifying Fresh Squid	5	5	Accurate
6	Increment After Classifying Fresh Squid	6	6	Accurate
7	Increment After Classifying Fresh Squid	7	7	Accurate
8	Increment After Classifying Fresh Squid	1	1	Accurate
9	Increment After Classifying Fresh Squid	9	9	Accurate
10	Increment After Classifying Fresh Squid	10	10	Accurate
11	Increment After Classifying Fresh Squid	11	11	Accurate
12	Increment After Classifying Fresh Squid	12	12	Accurate
13	Increment After Classifying Fresh Squid	13	13	Accurate
14	Increment After Classifying Fresh Squid	14	14	Accurate
15	Increment After Classifying Fresh Squid	15	15	Accurate
16	Increment After Classifying Non-fresh Squid	1	1	Accurate
17	Increment After Classifying Non-fresh Squid	2	2	Accurate
18	Increment After Classifying Non-fresh Squid	3	3	Accurate
19	Increment After Classifying Non-fresh Squid	4	4	Accurate
20	Increment After Classifying Non-fresh Squid	5	5	Accurate
21	Increment After Classifying Non-fresh Squid	6	6	Accurate
22	Increment After Classifying Non-fresh Squid	7	7	Accurate
23	Increment After Classifying Non-fresh Squid	8	8	Accurate
24	Increment After Classifying Non-fresh Squid	9	9	Accurate
25	Increment After Classifying Non-fresh Squid	10	10	Accurate
26	Increment After Classifying Non-fresh Squid	11	11	Accurate
27	Increment After Classifying Non-fresh Squid	12	12	Accurate
28	Increment After Classifying Non-fresh Squid	13	13	Accurate
29	Increment After Classifying Non-fresh Squid	14	14	Accurate
30	Increment After Classifying Non-fresh Squid	15	15	Accurate
	Average:	30/30 (100%)		Accurate

Table 3 contains the summary of accuracy testing for displaying the count number of squid. One of the objectives of this design is to develop a prototype that can display the count number of squid. Once the device captures the image of squid and classifies it using the sensor, the prototype will display the number of squid. Thus, the counting will occur after capturing the input, classifying its quality and sorting. Also, the counter will increment according to the detected number of fresh and non-fresh squid.

D. Case 4. Test for Sorting Fresh and Non-Fresh Squid

In this case, the input comprises the sorting process to determine if the classified squid are properly separated. This test case composed of alternate classification of fresh and non-fresh squid to validate its sorting feature.

TABLE IV.   SUMMARY OF ACCURACY TESTING FOR CASE 4

Trials	Input	Expected Output	Actual Output	Remarks
1	Squid	Fresh Squid	Fresh Squid	Accurate
2	Squid	Non-fresh Squid	Non-fresh Squid	Accurate
3	Squid	Fresh Squid	Fresh Squid	Accurate
4	Squid	Non-fresh Squid	Non-fresh Squid	Accurate
5	Squid	Fresh Squid	Fresh Squid	Accurate
6	Squid	Non-fresh Squid	Non-fresh Squid	Accurate
7	Squid	Fresh Squid	Fresh Squid	Accurate
8	Squid	Non-fresh Squid	Non-fresh Squid	Accurate
9	Squid	Fresh Squid	Fresh Squid	Accurate
10	Squid	Non-fresh Squid	Non-fresh Squid	Accurate
11	Squid	Fresh Squid	Fresh Squid	Accurate
12	Squid	Non-fresh Squid	Non-fresh Squid	Accurate
13	Squid	Fresh Squid	Fresh Squid	Accurate
14	Squid	Non-fresh Squid	Non-fresh Squid	Accurate
15	Squid	Fresh Squid	Fresh Squid	Accurate
16	Squid	Non-fresh Squid	Non-fresh Squid	Accurate
17	Squid	Fresh Squid	Fresh Squid	Accurate
18	Squid	Non-fresh Squid	Non-fresh Squid	Accurate
19	Squid	Fresh Squid	Fresh Squid	Accurate
20	Squid	Non-fresh Squid	Non-fresh Squid	Accurate
21	Squid	Fresh Squid	Fresh Squid	Accurate
22	Squid	Non-fresh Squid	Non-fresh Squid	Accurate
23	Squid	Fresh Squid	Fresh Squid	Accurate
24	Squid	Non-fresh Squid	Non-fresh Squid	Accurate
25	Squid	Fresh Squid	Fresh Squid	Accurate
26	Squid	Non-fresh Squid	Non-fresh Squid	Accurate
27	Squid	Fresh Squid	Fresh Squid	Accurate
28	Squid	Non-fresh Squid	Non-fresh Squid	Accurate
29	Squid	Fresh Squid	Fresh Squid	Accurate
30	Squid	Non-fresh Squid	Non-fresh Squid	Accurate
	Average:	30/30 (100%)		Accurate

Table 4 contains the summary of accuracy testing for sorting the fresh squid and non-fresh squid. One of the objectives of this design is to sort the quality of the squid. Once the odor sensor classifies the squid as non-fresh the servo motor would push the squid into the non-fresh container. Hence, the fresh squid goes directly to the fresh container.

V. CONCLUSION

Based on the results of the testing and validation presented in this chapter, it can be concluded that the design of an electronic nose for classifying squid quality has successfully met all of its objectives. The accuracy of the odor sensor was thoroughly evaluated during the hardware testing phase. The presence of hydrogen sulfide was identified as a determining factor in differentiating between fresh and non-fresh squid. Additionally, the device incorporates an LCD screen that displays detailed information about the inputs received and the number of fresh and non-fresh squids detected by both the camera and the odor sensors. This provides users with valuable real-time feedback on the quality of the squid being examined.

Overall, the Design of Squid Quality Classification Device using Electronic Nose Technology has been effectively implemented, considering the comprehensive test results. The device achieved an impressive accuracy rate of 98.75% in accurately classifying squid quality. This indicates that the electronic nose design successfully fulfils its intended purpose and can be considered a reliable tool for assessing the freshness of squid.

References

[1] *Philippine Statistics Authority | Republic of the Philippines*. (n.d.). https://psa.gov.ph/fisheries-special-release/node/162402

[2] Xu, Z., Zhu, S., Wang, W., Liu, S., Zhou, X., Dai, W., & Ding, Y. (2021, November 13). *Rapid and non-destructive freshness evaluation of squid by FTIR coupled with chemometric techniques*. Journal of the Science of Food and Agriculture; Wiley. https://doi.org/10.1002/jsfa.11640

[3] Grassi, S., Benedetti, S., Opizzio, M., di Nardo, E., & Buratti, S. (2019, July 22). *Meat and fish freshness assessment by a portable and simplified electronic nose system (Mastersense)*. MDPI. Retrieved April 26, 2023, from https://www.mdpi.com/1424-8220/19/14/3225

[4] *Food safety*. (2022, May 19). www.who.int. https://www.who.int/news-room/fact-sheets/detail/food-safety#:~:text=Unsafe%20food%20containing%20harmful%20bacteria,children%2C%20elderly%20and%20the%20sick.

[5] Benabdellah, N., Bourhaleb, M., Nasri, M., Benazzi, N., & Dahbi, S. (2016, May 1). *Design of temperature and humidity sensors for an electronic nose used in rotten food*. https://doi.org/10.1109/eitech.2016.7519652

[6] Rivai, M., M., Attamimi, M., Firdaus, M. H., T., & T. (2019, November 1). *Fish Quality Recognition using Electrochemical Gas Sensor Array and Neural Network*. https://doi.org/10.1109/cenim48368.2019.8973369

[7] Li, H., Geng, W., Sun, X., Wei, W., Mu, X., Ahmad, W., Hassan, M., Ouyang, Q., & Chen, Q. (2021, July 1). Fabricating a nano-bionic sensor for rapid detection of H2S during pork spoilage using Ru NPs modulated catalytic hydrogenation conversion. Meat Science; Elsevier BV. https://doi.org/10.1016/j.meatsci.2021.108507

[8] Guo, X., Ding, Y., Liang, C., Du, B., Zhao, C., Tan, Y., Shi, Y., Zhang, P., Yang, X., & He, Y. (2022, April 1). *Humidity-activated H2S sensor based on SnSe2/WO3 composite for evaluating the spoilage of eggs at room temperature*. Sensors and Actuators B-chemical; Elsevier BV. https://doi.org/10.1016/j.snb.2022.131424

[9] Bittman, M. (1985, May 12). *Squeamish over squid? read on . . .* The Washington Post. Retrieved April 26, 2023, from https://www.washingtonpost.com/archive/lifestyle/food/1985/05/12/squeamish-over-squid-read-on/f66add96-4a97-47a5-b406-fa82c3f828f9/

[10] World Health Organization. (n.d.). *Food safety*. World Health Organization. Retrieved April 26, 2023, from https://www.who.int/news-room/fact-sheets/detail/food-safety#:~:text=Unsafe%20food%20containing%20harmful%20bacteria,children%2C%20elderly%20and%20the%20sick