Faculty of Electrical Technology and Engineering

DEVELOPMENT OF SEAFOOD DRYING MECHANISM USING ARDUINO CONTROLLER

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Bachelor of Electrical Engineering Technology (Industrial Automation & Robotics) with Honours

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A project report submitted
in partial fulfillment of the requirements for the degree of
Bachelor of Electrical Engineering Technology (Industrial Automation & Robotics) with Honours

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DEDICATION

This work is dedicated to my dear parents, Father Mokhtar Bin Khamis and Mother Razimah Binti Abdul Razak, for their everlasting support. Special thanks to my elder sister, Marliyana Binti Mokhtar, as well as Marzuwani Binti Mokhtar and Murfiqah Binti Mokhtar, for their important support and direction in my endeavors. Your everlasting trust in me is much appreciated.

ABSTRACT

The traditional method of seafood drying typically takes around three days under sunny conditions for the food to achieve the desired dryness. However, issues arise when humidity levels are high, causing the food to stiffen rapidly. Additionally, the open environment used in the traditional method is prone to contamination, as dust, bacteria, and flies can easily enter the drying space. To address these challenges, an Arduino UNO is employed in this project to program instructions and control the system. The Arduino UNO interfaces with temperature and humidity sensors within the box, allowing for precise monitoring of environmental conditions. The drying duration is determined based on these sensor readings: if the temperature exceeds 28 degrees Celsius and 33 degree Celsius, the project initiates a 24-hour drying cycle and 12-hour cycle; conversely, if the temperature falls below 27 degrees Celsius, the project engages in a 48-hour drying cycle. To enhance the efficiency of the drying process, a fan is incorporated to ensure uniform air circulation within the box. Additionally, warm lamps are utilized to heat the seafood, reducing drying time. The project dimensions measure 35 cm x 35 cm x 32 cm, providing a compact and controlled environment for the food drying process. These technological improvements aim to maintain cleanliness, mitigate contamination risks, and expedite the drying process for better overall results.

ABSTRAK

Kaedah tradisional pengeringan makanan laut biasanya mengambil masa kira-kira tiga hari di bawah keadaan matahari untuk mencapai kering yang diinginkan. Walaubagaimanapun, masalah timbul apabila tahap kelembapan tinggi, menyebabkan makanan menjadi keras dengan cepat. Selain itu, persekitaran terbuka yang digunakan dalam kaedah tradisional mudah terdedah kepada pencemaran, kerana debu, bakteria, dan lalat dengan mudah boleh masuk ke dalam ruang pengeringan. Bagi menangani cabaran ini, Arduino UNO digunakan dalam projek ini untuk memprogram arahan dan mengawal sistem. Arduino UNO berinteraksi dengan sensor suhu dan kelembapan di dalam kotak, membolehkan pemantauan yang tepat terhadap keadaan alam sekitar. Tempoh pengeringan ditentukan berdasarkan bacaan sensor ini: jika suhu melebihi 28 darjah Celsius dan 33 darjah Celsius, projek memulakan kitaran pengeringan 24 jam dan 12 jam; sebaliknya, jika suhu jatuh di bawah 27 darjah Celsius, projek memulakan kitaran pengeringan 48 jam. Untuk meningkatkan kecekapan proses pengeringan, kipas disertakan untuk memastikan sirkulasi udara yang seragam di dalam kotak. Selain itu, lampu panas digunakan untuk memanaskan makanan laut, mengurangkan masa pengeringan. Dimensi projek adalah 35 cm x 35 cm x 32 cm, menyediakan persekitaran yang padat dan terkawal untuk proses pengeringan makanan. Peningkatan teknologi ini bertujuan untuk mengekalkan kebersihan, mengurangkan risiko pencemaran, dan mempercepatkan proses pengeringan untuk hasil yang lebih baik secara keseluruhan.

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LIST OF SYMBOLS

°C	-	Celsius
%	-	Percentage
cm	-	Centimeter

LIST OF ABBREVIATIONS

LCD	-	Liquid Crystal Display
UV	-	Ultraviolet
H_2U	-	Humidititification Unit

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

Solar drying is one of the drying traditional method used since long time ago. The product is immediately exposed to sun rays in this process, allowing it to be dried by solar radiation. Solar dryers developed from the principle of solar drying. A solar dryer works based on passing dry, hot air heated by solar energy over objects to be dried. Solar drying has shown to be a cost-effective and efficient alternative to traditional and mechanical drying techniques, particularly for places with significant sunlight, such as Malaysia.

Solar greenhouse dryers, solar cabinet dryers, forced convection dryers, and many more types of solar dryers have been invented to increase solar drying capabilities. However, one major issue with these solar dryers is their capacity to dry things only when solar energy is present, limiting their usage to only hot days. This project combines the usage of direct solar heat with a light to maintain the drying process although in the dark and foggy environment. The light allows water to evaporate while preserving the product's flavor, vitamins, and physiologically active components.

1.2 Problem Statement

Fruits, vegetables, and seafood are traditionally dried using a technique called solar drying, which takes three to four days. This technique has numerous drawbacks, including food spoilage caused by rain, wind, dust, insect invasion, animal harm, and fungus. The pace of drying, particularly in open sun drying, where solar radiation is exposed directly to the products, causes the product's exterior to harden before the wetness inside has a chance evaporate, which ends up affecting the quality of the dried product. Open solar drying also has a high labor cost and excessive crop handling, especially during bad weather, which can result in high costs, crop harm, and quality loss. In this study, design mechanism is developed for drying process to solve the issues and produce better quality product.

1.3 Project Objective

The main aim of this project is to design a systematic and effective methodology to estimate the accuracy of drying mechanism for seafood. Specifically, the objectives are as follows:

a. To develop a phototype drying mechanism for seafood using an Arduino controller.

b. To determine the suitable quantity of seafood that will be used during the system's operation.

c. To analyze the effect of weather and humidity on the designed controller using temperature and humidity sensor.

1.4 Scope of Project

The scope of this project are as follows:

a. The tray can hold up to 0.3 kilogram only.

b. The size of the seafood must not exceed 10.0 cm in length, 10.0 cm in width, and 3.0 cm in thickness.

c. Using a temperature sensor to detect the highest and lowest temperatures in the environment.

d. The Arduino system is used to supply energy to the sensor.

e. Using light to dry the seafood.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This vintage method is used to preserve seafood, particularly in rural regions. The elimination of moisture preserves edible seafood. The main idea of seafood drying is that the activity of the muscle enzyme and microbe is decreased to a bare minimum by revocation the water content of the seafood by traditional sun drying. Malaysian seafood handling and processing procedures are still traditional and should be improved significantly. To get high-quality dried seafood products, Malaysian seafood processors mostly employed traditional drying processes, and significant improvement was required at various stages of handling, processing, and shipping of fresh seafood. Most drying activities were done on a commercial basis. Those areas' sanitary conditions were deplorable. Even though the seafood drying locations were isolated from the surrounding area, the stink of dried seafood might pose a major health risk and damage the environment. This study used an LCD display to display the temperature and humidity of the surrounding environment, as well as a timer to indicate when the process is complete. Temperature and humidity sensors, Infrared Light, Arduino UNO, LCD display, and a timer are all used in the system.

2.2 Introduction of Drying Mechanism

A food drying system serves as vital for preserving food by eliminating moisture content and increasing its shelf life. It uses heat and airflow to speed up the evaporation of water from food, resulting in a dry product. Food drying systems have been used for millennia and continue to change with technological and scientific advances. Food drying systems use a variety of processes and technologies, including sun drying, air drying, solar drying, convection drying, and freeze drying. Sun drying is a traditional practice that uses sunshine to naturally dry food. It is often used for fruits and vegetables, as well as certain types of meat. Air drying, on the other hand, removes moisture by natural air circulation and is commonly used for herbs, spices, and some fruits and vegetables. Solar drying systems are ecologically friendly and energy-efficient since they use solar energy as a heat source. Solar collectors, air circulation devices, and drying chambers are common components of these systems. Convection drying, which involves the circulation of hot air using fans or blowers to promote drying, is a frequently utilised approach in industrial settings. It provides efficient and consistent drying but requires accurate temperature, ventilation, and humidity control. freeze drying, is a specialised procedure used to preserve fragile or heat-sensitive foods. It involves freezing the food at extremely low temperatures and eliminating moisture by sublimation, a process in which ice instantly transforms into water vapour. This process retains the original qualities of the food, such as form, colour, flavour, and nutritional value, but it requires specialised equipment and is rather expensive. [1]

Based on ongoing research in food drying systems, the objective is to increase efficiency, minimise energy consumption, and improve dried food product quality. Microwave drying, infrared drying, hoover drying, and hybrid drying methods are being investigated by researchers. These technologies have the potential to cut drying time, increase product quality, and prevent nutrient degradation. Mathematical modelling as well as simulation tools are being developed to anticipate and optimise drying processes. To improve drying efficiency and control, these models consider aspects such as food qualities, equipment design, and operating circumstances. The sensory characteristics, nutritional content, and functional aspects of dried foods are the subject of quality evaluation and optimisation study. The objective is to provide optimal drying conditions that retain the required attributes of the final product. [2]

2.3 Journal

Table 2-1 Journal of Previous Research

NO	AUTHOR	TITLE	YEAR	ABOUT
1.	Dan Huang	Application of infrared radiation in the drying of food products	2021	This research examined an infrared radiation in food drying. The parametric effects of infrared radiation (infrared power, intensity, wavelength, distance, and drying temperature) and the introduction of infrared radiation on drying kinetics and food quality were studied. [3]
2.	Kuldeep Singh Kaswan	Role Of Arduino in Real World Applications	2020	The information provided here is about Arduino applications based on the research topic explained.[4]

3.	Hind Krabch	Indirect solar dryer with a single compartment for food drying.	2022	Based on the research project described in this article, the results reveal that it is acceptable to achieve high temperatures within the dryer of up to 60 C and very low humidity levels. [5]
4.	Azhari	Design of Monitoring System Temperature and Humidity Using DHT22 Sensor and NRF24L01 Based on Arduino	2023	This project describes the Arduino Uno and the NRF24L01 wireless communication module. The NRF24L01 module is a reliable data transmission module, ensuring that the data received matches the data supplied by testing the module in different rooms and at 800 m. Buzzer performs effectively with temperature performance results of 32 °C buzzer on and humidity performance results of 65% humidity buzzer on.[6]

2.3.1 Infrared Light

Due to its capacity to efficiently remove moisture from diverse food items, infrared technology has been widely used in food drying systems. In comparison to traditional drying procedures, the utilisation of infrared radiation in food drying processes has various advantages. Infrared drying works on the principle of selective heating, in which the infrared radiation is absorbed by the moisture in the food and causes it to evaporate. When compared to traditional methods such as hot air convection drying, this focused heating strategy allows for faster and more uniform drying. Furthermore, infrared drying may be done at lower temperatures, preserving the nutritional content, colour, and flavour of the food.

According to another research, used infrared radiation to test the drying properties of apple slices. In comparison to hot air drying, the researchers discovered that infrared drying resulted in quicker drying durations and improved conservation of the apple's original colour. [7] Based on another research, focused on the drying of banana utilising an infrared-assisted drying method. The researchers discovered that infrared radiation considerably reduced drying time while retaining the necessary qualities of the banana, such as colour, rehydration capability, and sensory aspects.[8] Infrared drying has also been used on a variety of food products, including vegetables, herbs, cereals, and meat. It has been demonstrated to be particularly successful in lowering drying time and energy consumption while keeping nutritional content and sensory aspects of food. From of that, the use of infrared radiation in food drying systems has several advantages over traditional drying processes, including shorter drying periods, increased product quality, and energy efficiency. The experiments listed above demonstrate the successful use of infrared technology in food drying procedures.

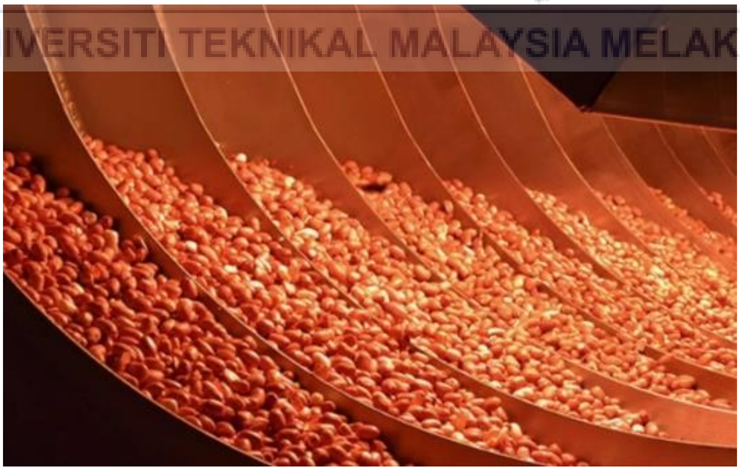


Figure 2-1 Drying Using Infrared

2.3.2 Arduino

Drying devices based on Arduino, a popular open-source microcontroller platform, provide a unique method to food drying. Arduino-based systems provide control and automation capabilities, allowing for accurate monitoring and modification of drying factors including as temperature, airflow, and humidity. These systems may be developed to provide constant and optimised drying conditions, resulting in increased efficiency and quality of dried food items. Arduino systems are versatile in terms of sensor integration, data gathering, and control algorithms. Temperature and humidity sensors may be included into the system to monitor the drying environment, ensuring that the correct conditions are maintained during the drying process. The acquired data may be utilised to dynamically modify factors like as fan speed, heating components, or ventilation to optimise drying efficiency.

The study is based on the research, in which an Arduino microcontroller was used to operate and monitor a sun drying system for fruit. Temperature and humidity sensors were used by the system to manage drying conditions and accomplish effective moisture removal. When compared to standard sun drying methods, the researchers observed improved drying performance, reduced drying time, and improved product quality.[9] Another study focused on using solar cells as energy sources for heating and fan (Ex house) in white copra dryers with Arduino Uno as temperature control. The system stated temperature sensors as well as a solar cell to power heaters and fans. The effective usage of microcontroller applications in temperature control system tools. When the white copra material is dry with the appropriate water content, the desiccant is supposed to monitor temperature changes directly in the drier and provide a warning with the led indication signal. [10]

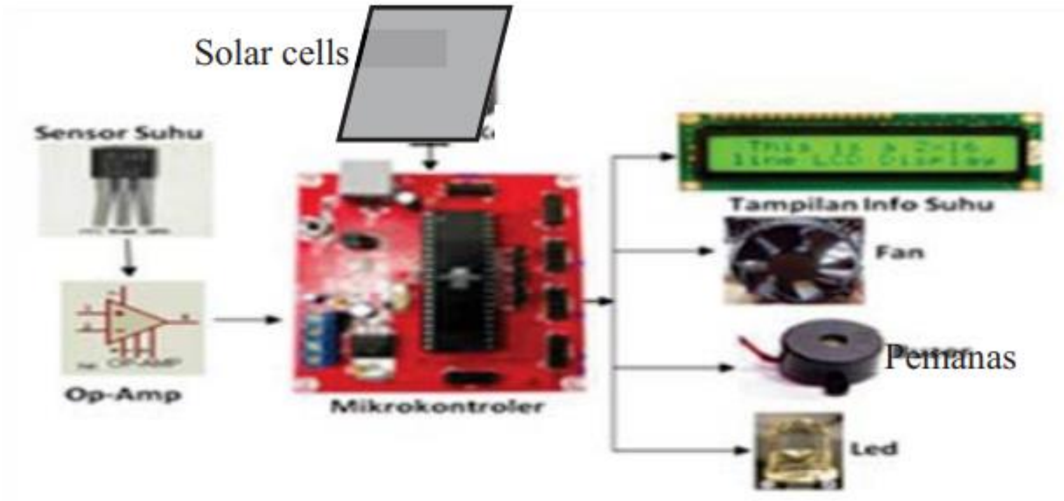


Figure 2-2 Block Diagram for Utilization of Solar Cells as Energy Sources for Heating and Fan (Exhouse) in White Copra Dryers

2.3.3 Weather

Weather conditions have a significant impact on the efficiency and efficacy of food drying systems. Temperature, humidity, and air movement are all meteorological characteristics that can have a considerable influence on the drying process and overall quality of dried food items. Temperature is an important factor in determining food drying rates. According to this research, the drying of eggplant and discovered that greater drying temperatures resulted in shorter drying periods and better product quality. [11] When those higher drying temperatures expedited moisture removal and resulted in superior overall drying properties when drying eggplant. [11] However, as demonstrated in this study on tomato drying with and without a solar tracking device, the quality of the dried sample might be affected. [12]

Humidity levels are also important in food drying. Low humidity promotes fast moisture evaporation, resulting in effective drying. This research discovered that drying some fruits at lower humidity levels enhanced the drying rate and resulted in higher-quality dried goods. High humidity levels, on the other hand, impede moisture removal, lengthen drying durations, and may promote microbial development and deterioration. [13] The drying process is greatly influenced by airflow. Adequate airflow promotes moisture removal from the food surface and avoids the establishment of unwanted microbiological growth. Insufficient ventilation, on the other hand, might result in uneven drying, mould growth, and off-flavour creation[14]. It is important to study local weather predictions and use weather monitoring equipment to acquire reliable weather information for food drying. It is possible to arrange drying activities effectively by monitoring temperature, humidity, and airflow patterns. Furthermore, the use of equipment such as digital thermometers and hygrometers aids in evaluating and taking control of the drying environment.

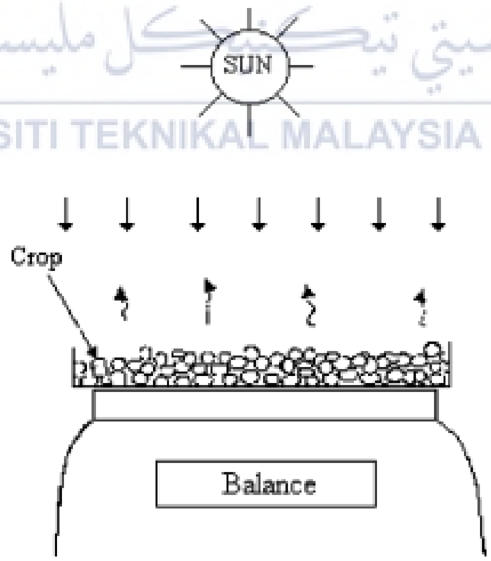


Figure 2-3 Experimental design for open drying

2.3.4 Temperature and Humidity sensor

Temperature and humidity sensors play an essential role in monitoring and managing the drying process, allowing for precise changes and better results. Most dryer systems operate and make decisions based on highly empirical recipes and rules that are typically too inflexible to respond to abrupt changes in process conditions, which is especially crucial in solar dryers. The implementation of these three proposed models on embedded electronics and wireless sensor networks will result in smart sensors, where data corresponding to the temperature and relative humidity of the air inside the kiln collected by Sensirion sensors, as well as wood temperature data from thermocouples, will allow for real-time estimation of the most important and complex parameters in thermal drying, such as drying rate and wood moisture. [15]

In an experimental facility, an automatic humidification system is utilised to control the humidity and temperature of the air. This facility was constructed by the Pontifical Bolivarian University's Automation and Control for Agro-industrial Processes Laboratory, with the goal of simulating ambient air from various climatic zones and obtaining drying curves for a wide range of agro-industrial products. The machine features multiple temperature, humidity, and velocity sensors for air monitoring, as well as strain gauges to measure the weight of the goods being dried. Since the primary objective of the experimental equipment is to assess the performance of prototype dryers, it must create a significant amount of conditioned air. The temperature and humidity of the air are adjusted in real time by this machine.[16] Based on this experiment, the results are quite close to the actual air conditions. The machine can generate air with the same average temperature and humidity as Colombian cities with harsh climates. The graph shows humidity and a temperature diagram when the autonomous system uses an on/off technique to manage the variables of interest. In this case, the relative humidity of the air approaches 80%, but the temperature of the air exiting the H_2U unit remains about 35°C. After this point, the machine ceases humidifying and the air entry temperature in the conditioning ring is no longer controlled. [16]

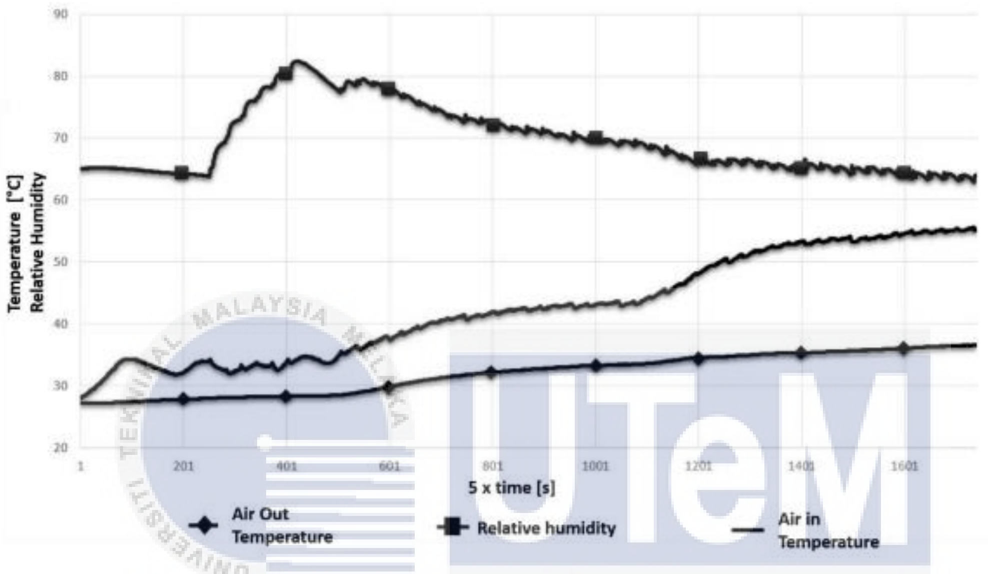


Figure 2-4 Data of Humidity and Temperature of air vs time. On/off control.

2.4 Comparison

Table 2-2 Comparison of Drying Methods

Method	**Outcome**	**Result**	**References**
Drying Based on Infrared	Infrared radiation enters the material being dried effectively, sending heat directly to its core. This controlled heating procedure enables faster and more uniform drying, greatly lowering drying durations when compared to standard methods.	60% of the time taken for the drying process.	[3], [7], [8], [17] – [19]
Drying system using Arduino controller	The Arduino controller enables accurate control and monitoring of drying factors including temperature, humidity, and airflow, resulting in ideal drying conditions. This type of control allows for more uniformity and precision in the drying process, resulting in higher product quality and shorter drying times.	50% of the time taken for the drying process.	[4], [9], [10]

Drying system using solar panel or direct sunlight	Solar panels transform the sun into electricity, giving the drying process a renewable and sustainable energy source. This environmentally friendly technique minimises dependency on traditional energy sources while also lowering carbon emissions. The ultimate result of a solar panel-powered drying system is not only cost-effective, but also extremely efficient, as it can function independently of grid power.	40% of the time taken for the drying process.	[5], [20], [21]
Drying system using hot air and microwave	Hot air heats quickly and uniformly, effectively eliminating moisture from the object being dried. It increases moisture evaporation and enables fast drying by producing a temperature differential. Microwave technology, on the other hand, complements hot air drying by transferring extra energy directly to the water molecules within the material, therefore speeding up the drying process. A drying system that uses hot air and microwave results in shorter drying periods, increased energy efficiency, and higher product quality.	80% of the time taken for the drying process.	[14], [22]

2.5 The Traditional Method

In the traditional method of fish drying, several meticulous steps are followed to ensure the quality and cleanliness of the final product. The process begins with the careful cleaning of the fish, involving the removal of scales and the contents of the stomach, achieved by delicately splitting the stomach open. This initial cleaning is crucial to maintain the fish in a pristine condition. Subsequently, the fish undergoes a thorough rinsing process, repeated twice to guarantee its cleanliness and overall quality.

Moving on to the next step, a container is filled with fish, and salt is generously sprinkled over them. This salting process is then repeated until all the fish are adequately covered. The containers are left undisturbed overnight, allowing the salt to work its preservative magic, enhancing the flavor and extending the shelf life of the fish.

After the salting phase, the fish undergo another round of rinsing, repeated twice, as a prelude to the drying process. The meticulous rinsing ensures that the excess salt is removed, preventing an overly salty taste in the final product. For the drying phase, all the fish are systematically arranged on a table to maximize exposure to the sun's rays. To expedite the drying process, the fish are turned over several times a day. This careful attention ensures that each side of the fish receives an adequate amount of sunlight, promoting even and efficient drying. The entire drying process typically spans a duration of 3 to 5 days, during which the fish gradually transform into fully dried, preserved delicacies. This time-honored method not only preserves the fish but also imparts a distinctive flavor that is cherished in culinary traditions.

Figure 2-5 Tradisional Method of Drying Seafood

2.6 Summary

During a comprehensive review of the literature on drying systems, multiple methods were discovered and analysed for their efficiency in creating efficient and ideal drying processes. Thus, infrared drying method with arduino microcontroller is chosen for this research since it uses infrared radiation to transfer heat directly to the product, resulting in quicker drying rates and less processing time. This technique is especially useful for heat-sensitive materials since it reduces thermal deterioration. Infrared drying is supposed to result in effective moisture removal, improved product quality, and lower energy use. By implementing the suitable drying method, it can contribute to the progress of drying systems in a variety of sectors.

CHAPTER 3

METHODOLOGY

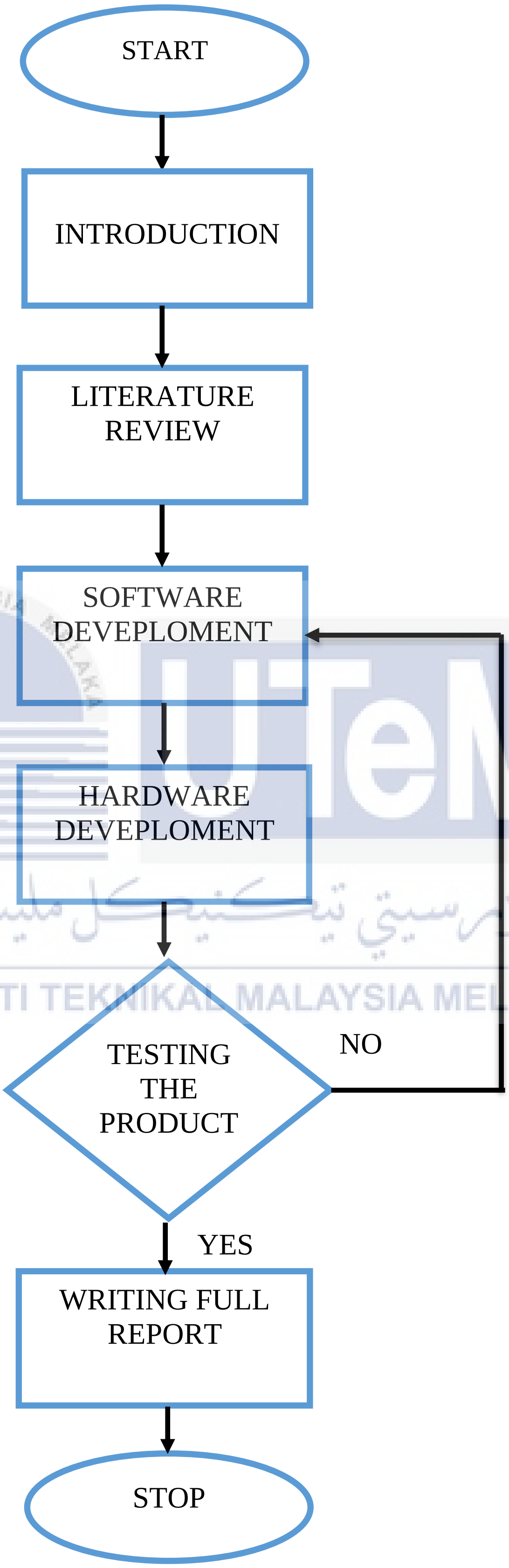
3.1 Introduction

An efficient and effective drying system is required in industries such as food processing, agriculture, medicines, and manufacturing. A proper methodology is essential to develop the systems, by taking consideration variables such as energy usage, product quality, and operational practicality.

3.2 Selecting and Evaluating Tools for a Drying Mechanism

It is important to thoughtfully choose and determine the tools and technologies that will be utilized for collecting and analyzing data while developing and implementing a seafood drying mechanism. This includes several kinds of methodological considerations, such as checking the accuracy and reliability of sensors, testing the compatibility of various tools and software, and the effect of environmental on the project. Furthermore, it is necessary to look at the project's social and economic consequences such as ensuring that the data is accessible and clear to numerous interested parties and considering the costs and advantages of various tool selections. There are several types of approaches that can be used to support these methodological considerations, such as conducting field tests to evaluate sensor accuracy, using free software to promote transparency and accessibility, and conducting life cycle assessments to evaluate the project’s environmental impacts.

3.3 Project Milestone



The project's purpose, objectives, and significance must be clear on the starting of the project’s development. The project starts with a thorough literature review regardly. This phase entails completing a thorough analysis of the current literature, academic publications, and other relevant sources regarding the project's subject area. The purpose of the literature review is to spot knowledge gaps and provide useful insights and theoretical frameworks to guide its path by reviewing and synthesizing the existing literature.

It is followed by software development in the next stage. This phase involves of the process of the framework of the project designing, developing. Following well-known software development approaches, such as Arduino and Wokwi, guarantees a methodical and effective approach throughout the development process. Next, the hardware development of the systems is planned. The required hardware components are chosen, prototyped, and their performance and compatibility with the software are optimized with great care. To achieve smooth integration and functionality, communication and cooperation between the software and hardware teams are essential.

The project moves into the testing phase after the software and hardware development is finished. To ensure that the product is functional, performs as expected, and complies with user criteria, testing is crucial. The project team can find and fix any problems or flaws by using a variety of testing approaches, including functional testing, performance testing, and user acceptance testing. The testing stage tries to confirm that the software performs as expected and communicates with the hardware successfully. However, if any flaws or issues are found during the testing phase, it is essential to go back and solve the software development stage. Before moving on, this method of iterating makes sure that the software and hardware parts have been improved and optimized.

3.4 Circuit Diagram and Component

Figure 3-1 shows a simple connection for seafood drying mechanism using Wokwi simulation software.

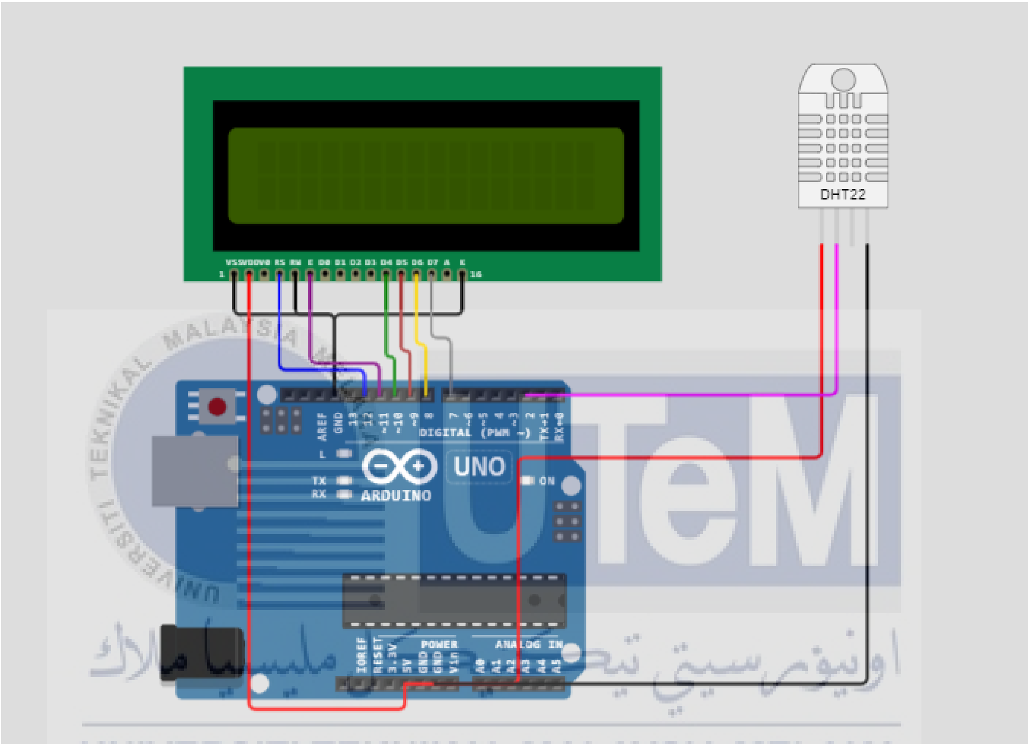


Figure 3-1 Circuit Diagram for Drying Mechanism

3.4.1 Arduino UNO

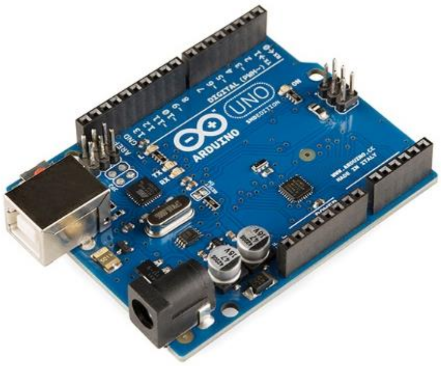


Figure 3-2 Arduino Uno

The Arduino will be programmed to control the drying system's temperature and humidity. It can communicate with sensors to monitor the environment and customize the drying settings accordingly. Additionally, the Arduino may be linked to a display device, allowing its consumers to observe the drying process in real time. It may examine critical data such as temperature, humidity levels, and drying time, which provides significant insight into the progress and effectiveness of the seafood drying mechanism.

3.4.2 Liquid Crystal Display (LCD)

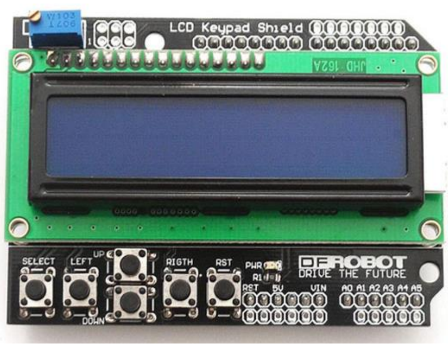


Figure 3-3 Liquid Crystal Display

To give a visual display of relevant data, an LCD module is usually linked to the Arduino controller. It may display important parameters including temperature, humidity levels, drying duration, and other variables related to the drying procedure. This real-time display use to monitor the drying process's progress and make modifications as needed. Furthermore, the LCD may be used to show alerts or cautions in the situation of any deviations or abnormalities throughout the drying process. For example, if the temperature exceeds a certain threshold or the humidity levels become extreme, the LCD can display warning messages to alert people. This helps to maintain the quality and safety of the dried seafood by keeping the drying conditions within the appropriate range.

3.4.3 Humidity and Temperature Sensor

Figure 3-4 DHT11 Humidity and Temperature Sensor

Moisture levels in the drying environment are measured using humidity sensors. The Arduino controller can effectively manage airflow and operate dehumidifiers as needed by continuously detecting humidity. This control mechanism ensures that the seafood is dried to the proper moisture level, which prevents rotting and maintains constant quality. The humidity sensor gives the Arduino real-time feedback, allowing it to make appropriate modifications and maintain an ideal drying atmosphere. To monitor and manage the drying temperature, temperature sensors are used. The Arduino can regulate the heat source, such as infrared heaters, to maintain the appropriate drying temperature by correctly monitoring the ambient temperature. The temperature sensor sends exact temperature measurements to the Arduino, which allows it to change the heating components and ensure that the seafood is dried at the correct temperature.

3.5 Hardware Component

This section provides a thorough overview of the hardware components that will be included in the system to carry out the system's intended features.

3.5.1 Metal Box

Figure 3-5 Metal Box

A metal box cover can provides a layer of insulation to the drying mechanism. Metal has high heat conductivity, which can aid in maintaining a constant internal temperature. This is especially significant for seafood drying, where temperature control is critical to attaining best outcomes. The metal box enclosure reduces temperature variations and creates a controlled atmosphere for drying.

3.5.2 Daylight Warm Light

Light serves a purpose in the seafood drying mechanism since it provides the energy required for the operation. When exposed to light, seafood absorbs the energy and converts it to heat. This mild heating speeds up the drying process by allowing moisture to evaporate from the seafood. Controlled light application aids in maintaining appropriate drying conditions, reducing overheating, and keeping the delicate texture, taste, and nutritious value of seafood. Essentially, light acts as a driving force, allowing for the effective elimination of water content and the manufacture of high-quality seafood dried items.

Figure 3-6 Daylight Warm Light

3.5.3 Mini Fan

Figure 3-7 Mini Fan

To boost airflow within the drying chamber, a small fan is used. It helps in the circulation of air, providing even heat and moisture distribution throughout the seafood. This breeze facilitates efficient drying by accelerating the evaporation of moisture from the surface of the seafood. The tiny fan can be strategically placed within the drying chamber to improve airflow and minimise stagnant air pockets. This reduces the establishment of moisture gradients and aids in the maintenance of constant drying conditions throughout the seafood. The small fan may be controlled and modified based on specified drying factors by integrating it with the Arduino controller. To produce the ideal drying atmosphere, the Arduino can modulate the fan's speed or activate it at specific intervals. This level of supervision guarantees that the seafood is dried evenly and efficiently. By ensuring appropriate air circulation, the small fan also helps to avoid the development of unwanted conditions such as mould or bacterial growth. It aids in the prevention of rotting and the creation of high-quality dried seafood products.

3.6 Summary

This chapter summarizes the suggested methods for creating an innovative, efficient, and comprehensive drying mechanism for seafood utilizing an Arduino controller. The proposed methodology's main goal is to carry out an efficient estimation that is straightforward and less demanding without significantly reducing the results' accuracy. After that, thorough testing was done to confirm the effectiveness and efficiency of the drying mechanism, making sure it dried the seafood efficiently while maintaining quality and safety. An iterative methodology was used throughout the project to allow for changes and modifications based on testing outcomes.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

The development of a seafood drying mechanism entails the use of modern drying technologies to maximize seafood preservation. Key data such as the mechanism's efficacy in preserving seafood, processing time, and related data are reported in the results section. This includes its capacity to keep dried seafood fresh, decrease rotting, and improve overall preservation. The discussion part goes into the consequences for seafood processing, strengths, limits, possibilities, and improvements. Environmental consequences and sustainability are considered as ethical issues. In addition, perceives on feedback from users, system usability, larger-scale practical implementation, encountered problems, and proposals for future enhancements are explored. This thorough examination evaluates the mechanism's usefulness, identifies its strengths and flaws, and offers suggestions for future refinement or implementation in comparable circumstances.

4.2 Results

This chapter displays the simulation results, the drying process results, and the hardware prototype design.

4.2.1 Wiring Circuit

Figure 4.-1 represents the wiring connection that has been constructed between the temperature and humidity sensor (DHT11), Liquid Crystal Display (LCD) and the Arduino UNO board.

Figure 4-1 Wiring Circuit

4.2.2 The Result Outcome

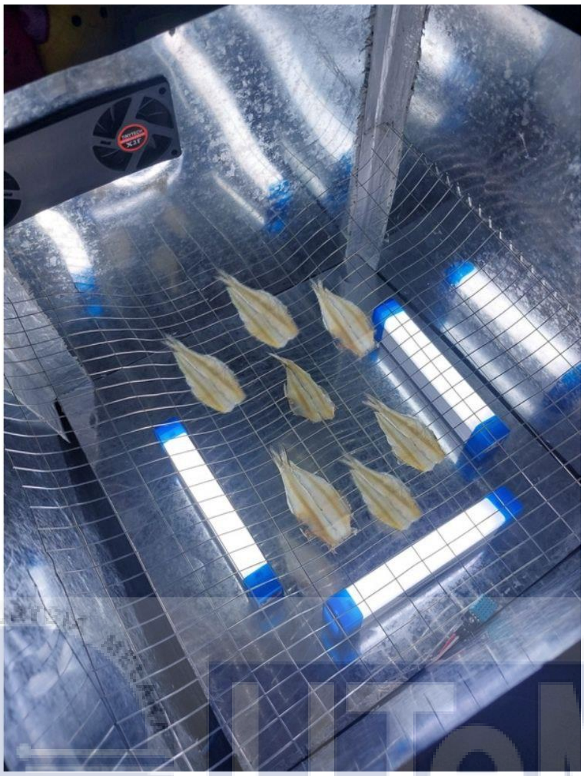


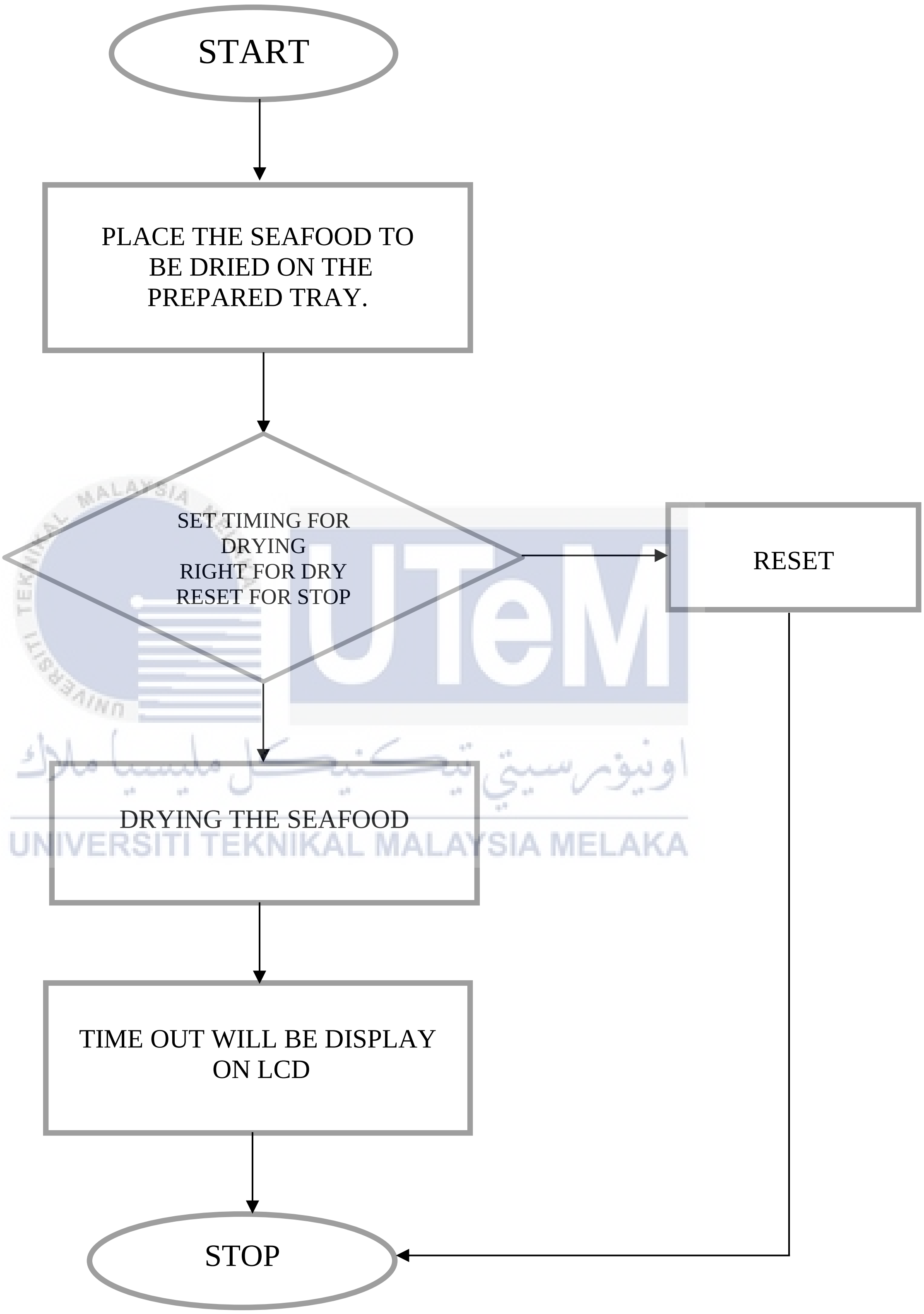
Figure 4-2 Result Outcome (Fish)

Figure 4-3 Result Outcome (Prawn)

Figure 4-4 Result Outcome (Fish and Prawn)

This system for seafood drying through observing ambient conditions with a DHT11 sensor. The temperature and humidity values are shown on an LCD screen in real time. A choose button activates the drying process, which employs a warm light to aid in the drying of seafood. The technology dynamically calculates and displays the remaining drying time on the LCD based on the temperature range observed (24-27°C , 28-32°C and 33-35°C). Furthermore, the system actively responds to temperature variations, terminating the drying process and showing an informational message on the LCD when the temperature falls outside of the prescribed limits. This not only gives precise feedback on the drying state, but also assures user-friendly control and management of the seafood drying process.

4.2.3 The Result Flowchart



4.2.4 Result and Analysis for Drying Process 3 Lamps and Hot Weather

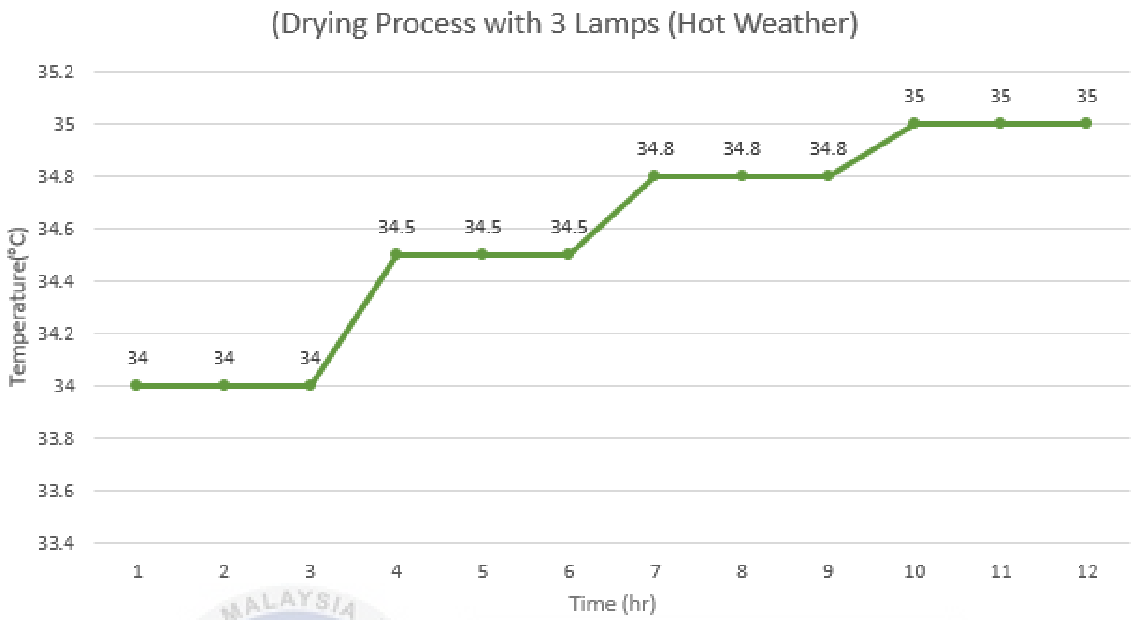


Figure 4-5 Graph Chart of Drying Process (Hot Weather)


Data3LampSeafood(Cuaca Panas).

File Edit View

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Temperature: 34.00°C, Humidity: 85.00%
Temperature: 34.00°C, Humidity: 85.00%
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Temperature: 34.00°C, Humidity: 85.00%
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Temperature: 34.50°C, Humidity: 80.00%
Temperature: 34.50°C, Humidity: 80.00%
Temperature: 34.50°C, Humidity: 80.00%
Temperature: 34.80°C, Humidity: 70.00%
Temperature: 34.80°C, Humidity: 70.00%
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Ln 17, Col 39 | 478,532 characters | 100% | Windows (CRLF) | UTF-8

Figure 4-6 Data of Drying Process (Hot Weather)

Based on the analysis of the presented graph and accompanying data, it is proved that the drying process in hot weather conditions, specifically when the temperature exceeds 34 degrees Celsius, remarkably requires a shorter duration of 12 hours to reach completion. Several factors contribute to this accelerated drying time, particularly owing to favorable environmental conditions and the augmenting effect of three lamps. Here is a detailed analysis outlining the reasons behind the expedited drying duration:

1. Optimal Temperature Conditions: The graph indicates that the drying process occurs under hot weather conditions, specifically at temperatures of 34 degrees Celsius and above. Such high temperatures are conducive to the evaporation of moisture from the seafood, providing an environment ideal for swift drying.
2. Role of 3 Lamps: The use of three lamps appears to be a significant contributing factor to the expedited drying process. The heat generated by these lamps facilitates a more rapid evaporation of moisture from the seafood, enhancing the overall efficiency of the drying process and resulting in a shorter drying duration.
3. Effective Heat Distribution: The configuration of three lamps likely contributes to more effective heat distribution within the drying box. This optimized heat distribution ensures that the seafood is uniformly exposed to the necessary heat, promoting consistent drying rates and reducing the overall time required for the process.
4. Optimized Environmental Factors: The environmental conditions, including temperature and humidity, seem to be optimized for the drying process. In this scenario, the environmental factors align favorably to support efficient moisture removal, minimizing obstacles that could otherwise extend the drying time.

The shortened drying time in hot weather conditions exceeding 34 degrees Celsius can be attributed to a combination of optimal temperature conditions, effective heat distribution facilitated by three lamps, and efficient moisture removal. The alignment of these factors creates an environment conducive to rapid drying, resulting in a significantly reduced drying duration.

4.2.5 Result and Analysis for Drying Process 2 Lamps and Hot Weather

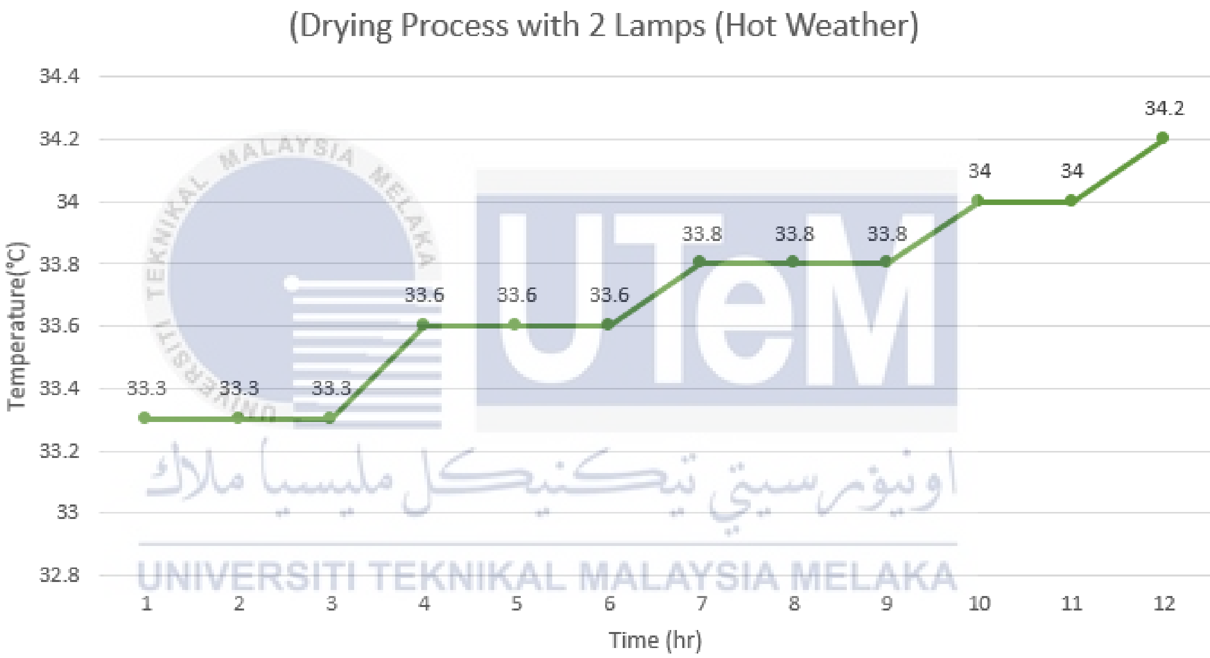
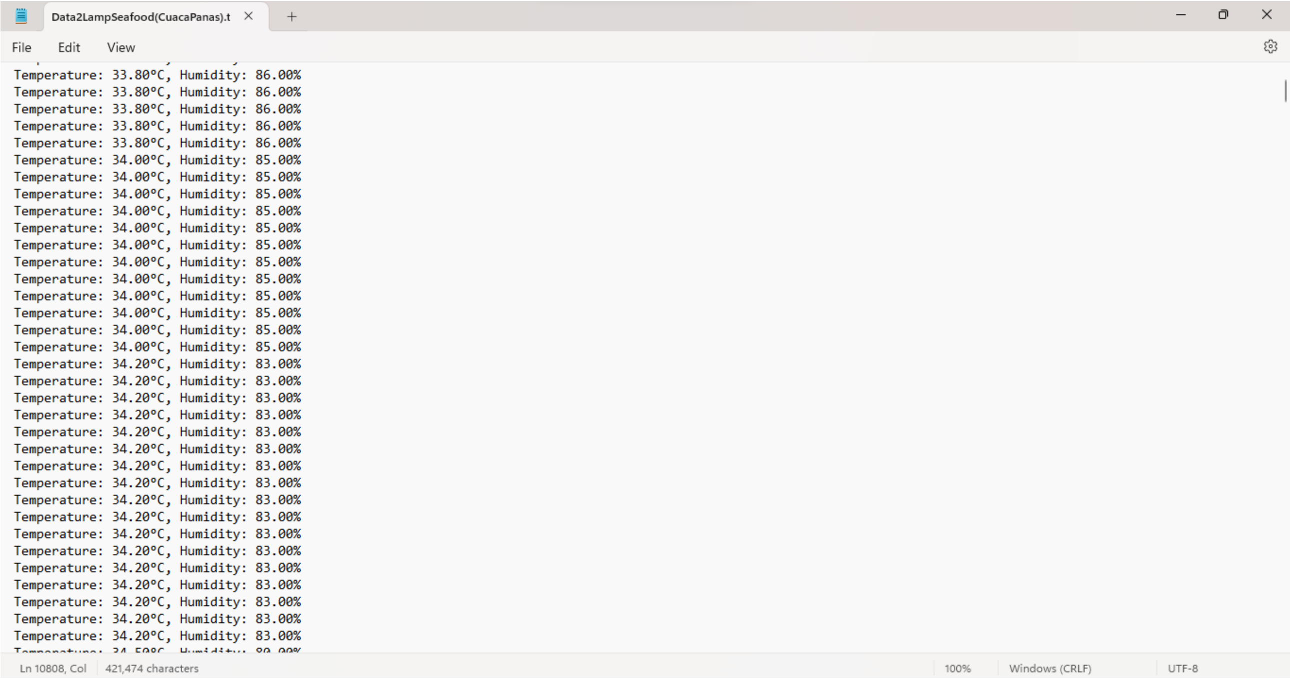


Figure 4-7 Graph Chart of Drying Process (Hot Weather)



Data2LampSeafood(CuacaPanas).t

File Edit View

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Temperature: 33.80°C, Humidity: 86.00%
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Figure 4-8 Data of Drying Process (Hot Weather)

From the provided graph and accompanying data, it is apparent that the drying process, occurring under hot weather conditions with temperatures surpassing 33 degrees Celsius, remarkably achieves a swift duration of 12 hours for completion. Several factors contribute to this accelerated drying time, with the interplay of favorable environmental conditions and the augmenting effect of two lamps playing pivotal roles. Here is an in-depth analysis elucidating the reasons behind the expedited drying duration:

1. Optimal Temperature Conditions: The graph illustrates that the drying process unfolds against a backdrop of scorching weather conditions, specifically at temperatures exceeding 33 degrees Celsius. The elevated temperature environment proves to be highly conducive to the rapid evaporation of moisture from the seafood, creating an ideal scenario for efficient and quick drying.

2. Temperature Consistency: In contrast to scenarios where temperature fluctuations pose challenges, the temperature remains notably stable and consistently high throughout the drying process. This stability plays a critical role in maintaining uniform drying rates across the seafood, contributing significantly to the overall efficiency of the drying process.
3. Role of 2 Lamps: The strategic use of two lamps emerges as a notable contributor to the hastened drying process. The generated heat from these lamps facilitates an accelerated evaporation of moisture from the seafood, enhancing the overall efficiency of the drying process and resulting in a significantly reduced drying duration.
4. Effective Heat Distribution: The configuration of two lamps is likely instrumental in facilitating an efficient distribution of heat within the drying box. This optimized heat dispersion ensures that the seafood experiences uniform exposure to the required heat, promoting consistent drying rates and ultimately reducing the overall time needed for the process.
5. Equipment Performance: The overall efficiency of the drying box and associated equipment in handling high temperatures and effectively distributing heat deserves recognition. In this case, the equipment appears to operate optimally, contributing significantly to the hastened drying process observed.

The abbreviated drying time in hot weather conditions exceeding 33 degrees Celsius can be attributed to a combination of optimal temperature conditions, efficient heat distribution facilitated by two lamps, and rapid moisture removal. The convergence of these factors creates an environment highly favorable to rapid drying, resulting in a significantly reduced overall drying duration.

4.2.6 Result and Analysis for Drying Process 3 Lamps and Humid Weather

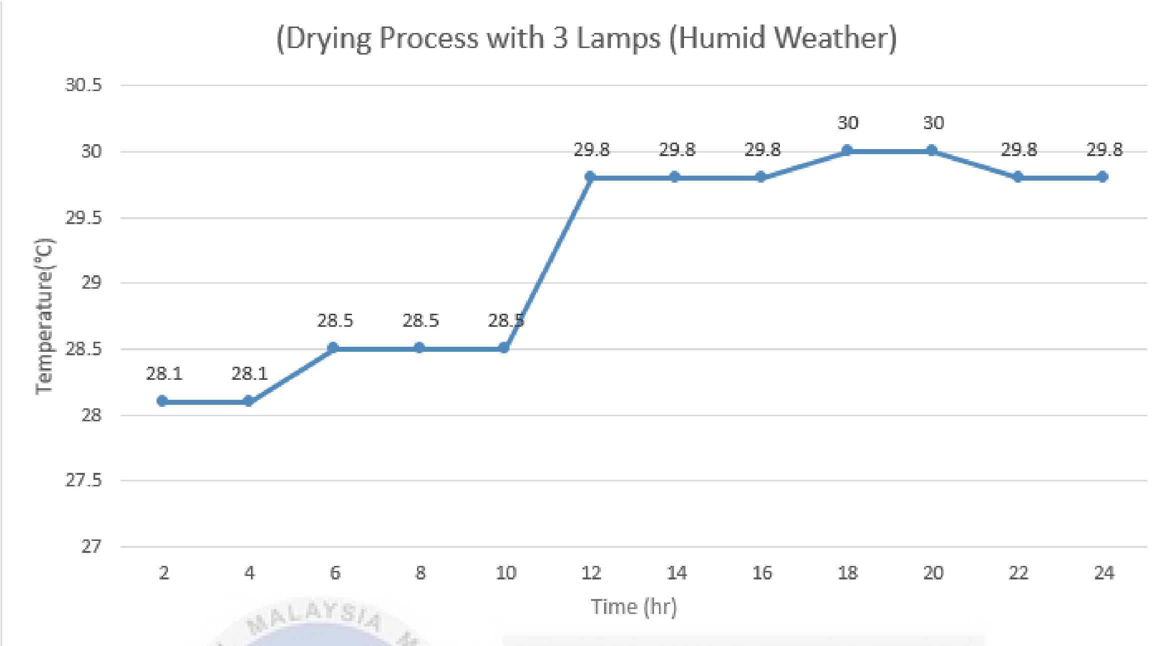

Figure 4-9 Graph Chart of Drying Process (Humid Weather)


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Temperature: 28.10°C, Humidity: 98.00%
Temperature: 28.10°C, Humidity: 98.00%
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Temperature: 28.10°C, Humidity: 98.00%
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Temperature: 29.80°C, Humidity: 95.00%
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Figure 4-10 Data of Drying Process (Humid Weather)

The presented graph and associated data, it is evident that the drying process in humid weather conditions, particularly when the temperature exceeds 29 degrees Celsius, requires an extended period of 24 hours to reach completion. Several factors contribute to this prolonged drying duration, mainly arising from disturbances in both the environmental conditions and the temperature control mechanisms within the drying box. Here's a detailed analysis outlining the reasons behind the extended drying time:

1. Humidity Impacts: In humid weather, the elevated moisture content in the air poses a significant challenge to the drying process. High humidity slows down the evaporation of moisture from the seafood, necessitating a more extended drying duration to achieve the desired dryness. The moisture-laden environment hampers the efficiency of the drying process.
2. Temperature Fluctuations: The graph reveals fluctuations in temperature, particularly when the ambient temperature rises above 29 degrees Celsius. These temperature variations may disrupt the overall drying process, affecting the uniformity of drying rates. Inconsistent temperatures contribute to the extended duration required for the seafood to reach the desired dryness.
3. Heat Dissipation Challenges: In humid weather conditions, efficient heat dissipation becomes crucial for maintaining optimal drying conditions. However, the high humidity may impede the effective dissipation of heat from the drying box, impacting the overall drying process and contributing to the observed prolonged duration.
4. Role of 3 Lamps: The use of three lamps appears to have a significant impact on shortening the drying process duration. The heat generated by the lamps contributes to expediting the evaporation of moisture from the seafood. The additional heat helps counteract the challenges posed by high humidity and temperature fluctuations, resulting in a more efficient and quicker drying process.
5. Optimized Heat Distribution:The configuration of three lamps likely contributes to more effective heat distribution within the drying box. This optimized heat

distribution helps ensure that the seafood is exposed to a consistent and adequate level of heat, promoting uniform drying rates and mitigating the impacts of environmental challenges.

6. Equipment Efficiency: The overall efficiency of the drying box and associated equipment in handling humid weather conditions needs careful consideration. Evaluating and potentially upgrading equipment can enhance temperature control, heat distribution, and overall performance, further contributing to a more efficient drying process.

The extended drying time in humid weather conditions exceeding 29 degrees Celsius is influenced by challenges such as high humidity, temperature fluctuations, and limited temperature control. The use of three lamps proves instrumental in mitigating these challenges, providing additional heat that helps expedite the drying process, ultimately leading to a shorter overall drying duration.

4.2.7 Result and Analysis for Drying Process 2 Lamps and Humid Weather

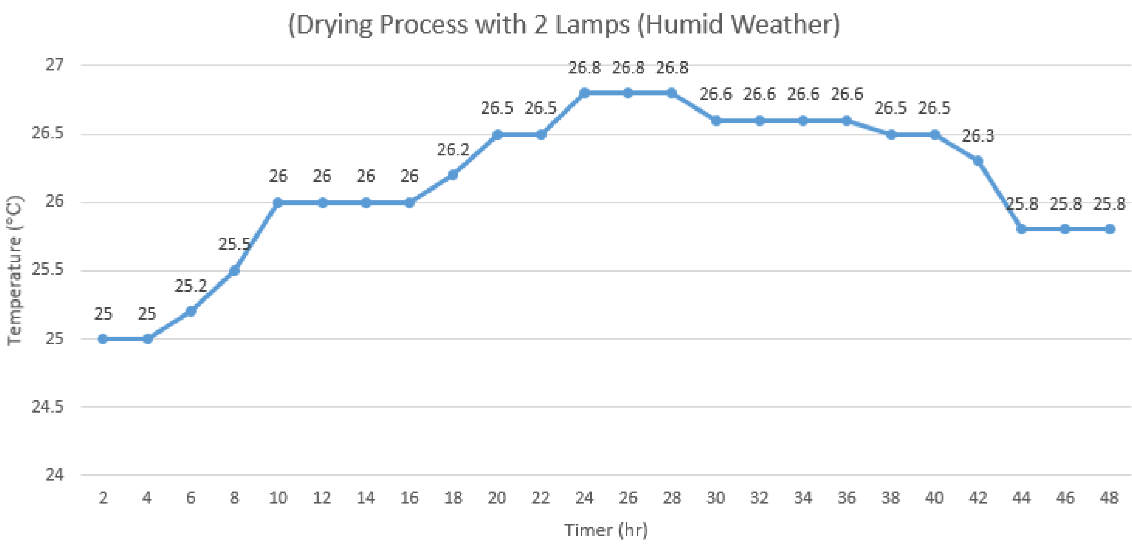

Figure 4-11 Graph Chart of Drying Process (Humid Weather)

Data2LampSeafood(CuacaLembap)

File Edit View

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Figure 4-12 Data of Drying Process (Humid Weather)

The provided graph and associated data, it is evident that the drying process in humid weather conditions, specifically when the temperature rises above 25 degrees Celsius, necessitates a protracted duration of 48 hours to reach completion. Several factors contribute to this extended drying time, primarily stemming from disturbances in both the environmental conditions and the temperature control mechanisms within the drying box. Here's a detailed analysis outlining the reasons behind the prolonged drying duration:

1. Humidity Challenges:In humid weather conditions, the presence of elevated moisture in the air significantly impedes the drying process. High humidity slows down the evaporation of moisture from the seafood, necessitating an extended drying duration to achieve the desired dryness. The moisture-laden environment hampers the efficiency of the drying process.
2. Temperature Fluctuations: The graph depicts fluctuations in temperature, particularly when the ambient temperature exceeds 25 degrees Celsius. These temperature variations may disrupt the overall drying process, affecting the uniformity of drying rates. Inconsistent temperatures contribute to the extended duration required for the seafood to reach the desired dryness.
3. Limited Temperature Control: The observed temperature fluctuations suggest limitations in the temperature control mechanisms of the drying box. Inadequate control over the drying environment can result in uneven heat distribution, hindering uniform moisture removal and contributing to the prolonged drying period.
4. Heat Dissipation Challenges: In humid weather conditions, efficient heat dissipation becomes crucial for maintaining optimal drying conditions. However, the high humidity may impede the effective dissipation of heat from the drying box, impacting the overall drying process and contributing to the observed prolonged duration.
5. Role of 2 Lamps: Surprisingly, the use of two lamps appears to have an adverse impact on the drying process, resulting in a longer duration than the actual time taken without the lamps. The heat generated by the lamps may not be sufficient to

counteract the challenges posed by high humidity and temperature fluctuations, leading to a less efficient drying process.

6. Ineffective Heat Distribution:The configuration of two lamps may contribute to less effective heat distribution within the drying box. This suboptimal heat distribution can result in uneven exposure of seafood to heat, further hindering uniform drying rates and contributing to the overall extended drying time.
7. Insufficient Heat Assistance: The heat provided by the two lamps might be insufficient to expedite the drying process effectively. In a high-humidity environment, additional heat is crucial for overcoming the challenges of moisture-laden air and ensuring efficient moisture removal, which may not be achieved with the use of two lamps.
8. Equipment Efficiency: The overall efficiency of the drying box and associated equipment in handling humid weather conditions requires careful evaluation. Upgrading equipment to enhance temperature control, heat distribution, and overall performance is essential to mitigate the challenges posed by humidity and temperature fluctuations, ultimately reducing the drying duration.

The extended drying time in humid weather conditions exceeding 25 degrees Celsius is influenced by challenges such as high humidity, temperature fluctuations, and limited temperature control. Surprisingly, the use of two lamps appears to have a counterproductive effect, resulting in a longer drying duration.

4.3 Hardware Design

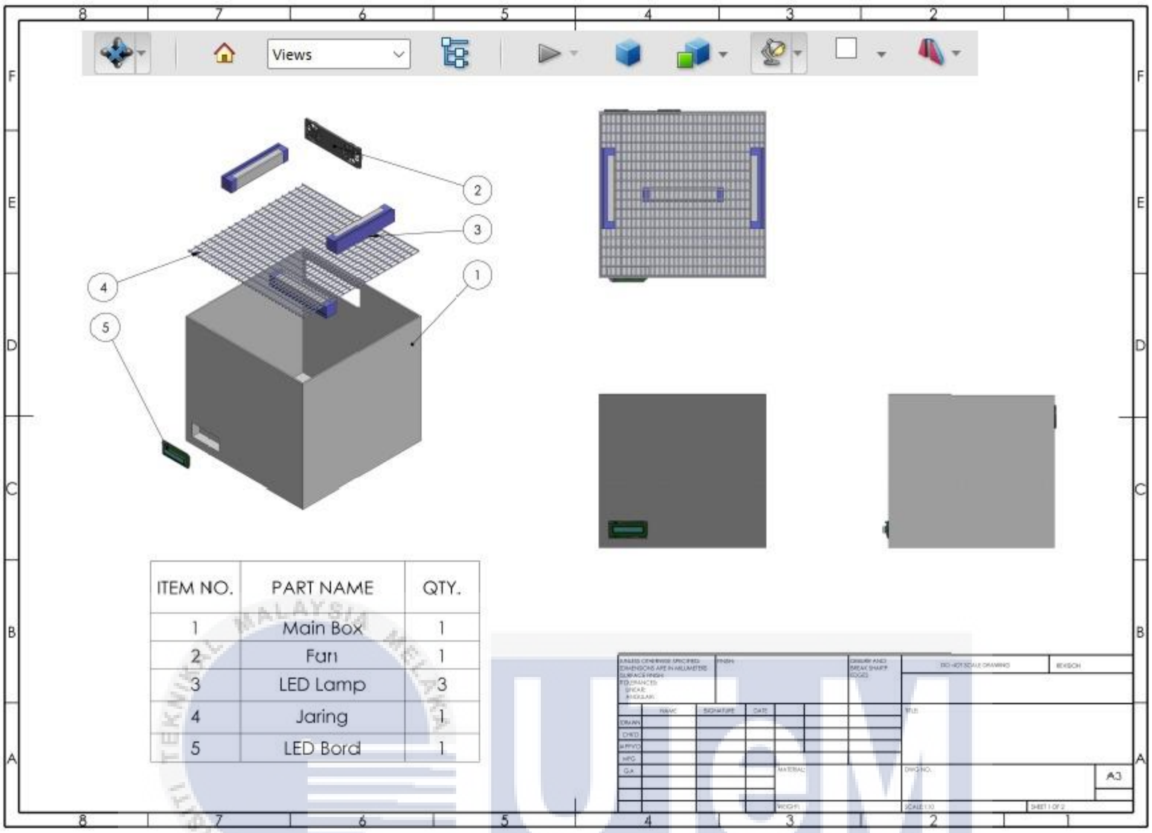

Figure 4-13 Design of Drying Mechanism

Figure 4-4 shows the design fot this project concept for seafood drying mechanism. The dimensions for this initial prototype design are 35 cm x 35 cm x 32 cm.

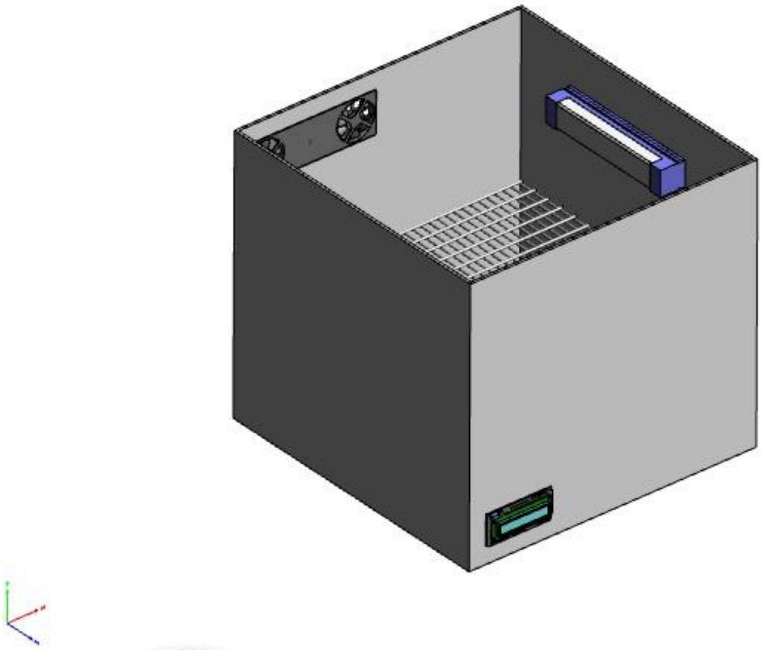

Figure 4-14 3D Design of Drying Mechanism

Figure 4-5 shows the 3D design fot this project concept for seafood drying mechanism.

4.4 Discussion

The examination of the seafood drying process, under varying environmental conditions and lamp configurations, provides nuanced insights into the factors influencing the efficiency of this crucial food preservation technique. One notable finding is the impact of temperature on drying duration. In hot weather conditions exceeding 33 degrees Celsius, the drying time is significantly reduced to a swift 12 hours, underscoring the favorable influence of elevated temperatures on expediting moisture evaporation. Conversely, when the temperature hovers around 25 degrees Celsius in humid conditions, the drying process extends to 48 hours, highlighting the challenges posed by increased humidity and less favorable temperature conditions.

The role of lamps in the drying process adds a layer of complexity. While the strategic use of three lamps contributes to a notable reduction in drying time, the unexpected outcome emerges when two lamps are employed, resulting in a longer drying duration. This underscores the importance of not only the quantity but also the configuration and heat distribution capabilities of lamps in optimizing the drying process. Efficient equipment performance and potential upgrades are identified as critical factors for maintaining consistent temperature conditions and overcoming challenges posed by environmental factors. The findings, thus, provide valuable insights for refining seafood drying practices in real-world applications.

In practical terms, these insights have implications for the development of adaptive strategies in seafood drying protocols. The need for a nuanced understanding of the interplay between environmental factors and equipment efficiency is emphasized, urging practitioners to consider tailored approaches based on specific conditions. Moreover, ethical considerations related to sustainability, energy consumption, and potential impacts on product quality should be integral to the implementation of seafood drying technologies. As we navigate the complexities revealed by this analysis, the goal remains to optimize seafood drying processes while ensuring responsible and environmentally conscious practices.

4.5 Summary

In this chapter, a comprehensive analysis of the seafood drying process has been conducted, considering various environmental conditions and lamp configurations. The study has unveiled key insights into the factors influencing drying times. Notably, the impact of temperature on the drying duration is highlighted, with hot weather conditions exceeding 33 degrees Celsius significantly reducing drying time to 12 hours, while humid conditions at 25 degrees Celsius extend the process to 48 hours. The role of lamps is examined, revealing that the strategic use of three lamps accelerates drying, whereas two lamps unexpectedly lengthen the process, emphasizing the importance of lamp configuration and heat distribution. Equipment efficiency and potential upgrades emerge as crucial factors for overcoming environmental challenges. These findings provide practical implications for refining seafood drying practices in real-world applications, emphasizing the need for adaptive strategies and ethical considerations to balance efficiency and sustainability.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The development of a drying mechanism for seafood which involves an Arduino controller and light technology is a significant achievement in the seafood industry. An efficient and regulated drying process for seafood is achieved by combining the precision and automation capabilities of the Arduino controller with the focused heating features of light technology. The new technique has various advantages, including increased drying efficiency, higher product quality, and prolonged shelf life. The Arduino controller enables accurate control of drying variables such as temperature, humidity, and airflow, resulting in ideal drying conditions for various varieties of seafood. Light technology is used to provide quick and consistent heating, efficiently eliminating moisture while retaining the inherent tastes and nutritional value of the seafood. Furthermore, the use of an Arduino controller and light technology allows for scalability, making it suitable to different production sizes in the seafood business. This development, with the potential to revolutionize seafood drying processes, has enormous promise for improving productivity, lowering energy consumption, and satisfying the growing demand for high-quality dried seafood products in a sustainable way.

5.2 Potential for Commercialization

The development of a drying mechanism for seafood using an Arduino controller and light technology has great marketing potential. This unique technology solves critical difficulties in the seafood sector, such as product quality preservation, shelf-life extension, and efficient drying operations. Because of the use of an Arduino controller, it is suited for both small-scale and large-scale seafood processing operations. This versatility opens the door to commercial uses in a variety of industries, including seafood processing plants, restaurants, and retail marketplaces. Light technology enables speedy and uniform heating, which results in better drying efficiency and consistent product quality. Because of these benefits, the invented drying method is very marketable, as it may increase production, reduce energy consumption, and fulfill the growing customer demand for high-quality, ecologically processed seafood. With more study and development, the commercialization potential of this revolutionary drying mechanism based on an Arduino controller and light technology appears promising, placing it as a viable solution for the seafood sector and beyond.

5.3 Future Work

Future work on this innovative seafood drying mechanism could focus on refining and expanding its capabilities. Firstly, enhancing the automation features of the Arduino controller to incorporate machine learning algorithms could optimize the drying process further. This could involve developing a smart system that adapts to changing ambient conditions, ensuring consistently optimal drying conditions. Additionally, investigating the integration of advanced sensors and real-time monitoring systems could provide more comprehensive data on variables like seafood thickness and moisture content. This data could then be used to dynamically adjust drying parameters for different types of seafood, improving precision and adaptability. Exploring alternative light technologies, such as infrared or microwave heating, may also contribute to the efficiency and speed of the drying process. Assessing the energy efficiency and environmental impact of these technologies could be crucial for sustainability. Collaboration with experts in food science and nutrition could lead to insights on how to preserve not only the texture but also enhance the nutritional content of the dried seafood products. Furthermore, scaling up the system for industrial use and conducting cost-benefit analyses would be essential for practical implementation. Considerations for energy consumption, cost-effectiveness, and ease of integration into existing seafood processing facilities could be addressed in future research. Ultimately, the continuous improvement and innovation in this seafood drying project could lead to a more sustainable, efficient, and versatile solution for the seafood industry, meeting the increasing demand for high-quality dried seafood products.

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APPENDICES

Appendix A Gantt Chart

PSM 1

NO	ACTIVITIES	DURATION (WEEK)													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Meeting with Supervisor														
2	Project Title Selection														
3	Introduction														
4	Literature Review														
6	Methodology														
7	Preliminary Results														
8	Conclusion														
9	Prepare For Presentation														
10	Presentation														

PSM 2

NO	ACTIVITIES	DURATION (WEEK)													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Introduction														
2	Literature Review														
3	Methodology														
4	Results analysis and Discussion														
5	Conclusion														
6	Final Report														
7	Prepare For Presentation														
8	Presentation														

Appendix B Drying Process Coding

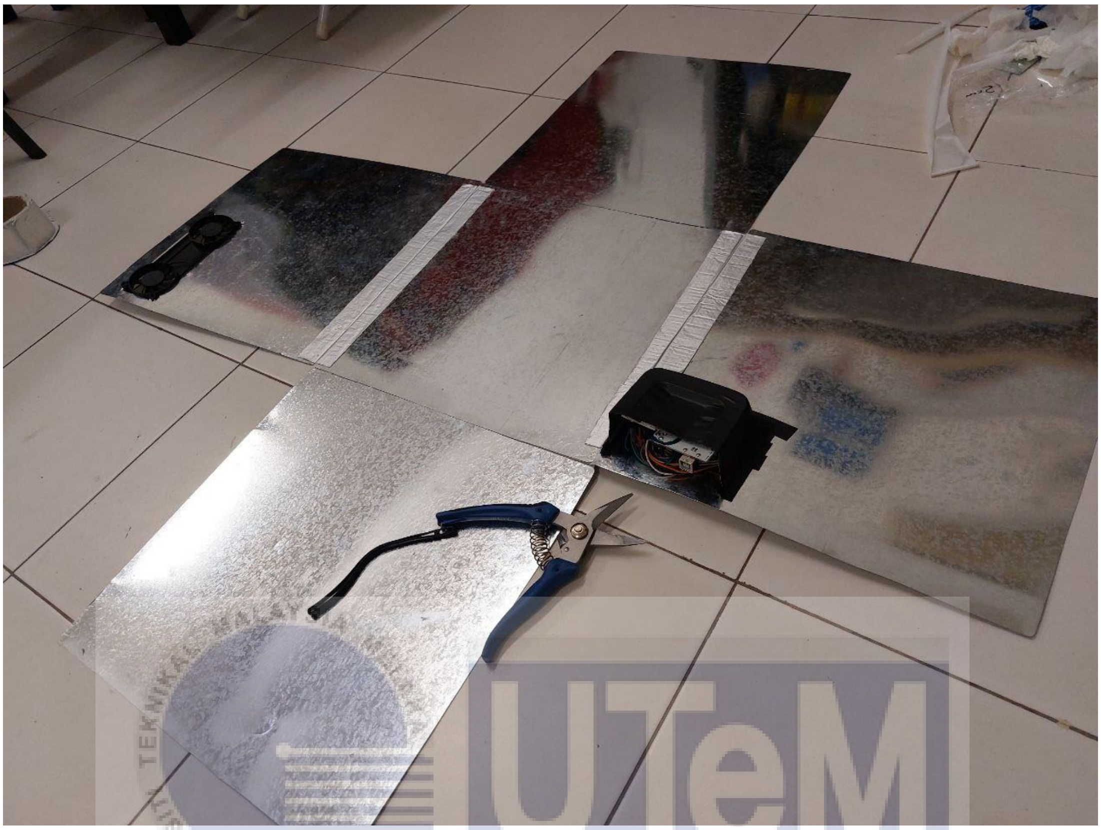
```
#include "DHT.h"
#include <LiquidCrystal.h>

#define DHTPIN 2      // DHT sensor pin
#define DHTTYPE DHT11  // DHT sensor type
#define SELECT_BUTTON_PIN A0  // Replace A0 with the actual pin number

DHT dht(DHTPIN, DHTTYPE);
LiquidCrystal lcd(8, 9, 4, 5, 6, 7);

unsigned long startTime = 0;
int dryingTimeLow = 47;   // 48 hours temp 24-27
int dryingTimeMiddle = 23;  // 24  hours temp 28-32
int dryingTimeHigh = 11;  // 12 hours temp 33-35
bool dryingInProgress = false;

void setup() {
  Serial.begin(9600);
  dht.begin();
  lcd.begin(16, 2);
  lcd.print("Drying Mechanism");
}

void loop() {
  lcd.setCursor(0, 1);
  lcd.print("Press to Start");
  int btnReading = analogRead(SELECT_BUTTON_PIN);
  delay(500);

  if (btnReading <= 900) {
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("MUSFIRAH 4BEEAS1");
    lcd.setCursor(0, 1);
    lcd.print("DRYRGT RESETRST");
    delay(1000);

    // Check if the select button is pressed
    btnReading = analogRead(SELECT_BUTTON_PIN);
    delay(500);

    if (btnReading >= 0 && btnReading <= 100) {
      float temperature, humidity;

      while (true) {
        // Read temperature and humidity
        temperature = dht.readTemperature();
```

```
humidity = dht.readHumidity();

// Display temperature and humidity
lcd.setCursor(0, 0);
lcd.print("T:");
lcd.print(temperature);
lcd.print("C H:");
lcd.print(humidity);
lcd.print("%");

// Print the values to the Serial Monitor
Serial.print("Temperature: ");
Serial.print(temperature);
Serial.print("°C, Humidity: ");
Serial.print(humidity);
Serial.println("%");

// Check if the temperature is in the specified range
if (temperature >= 24 && temperature <= 27) {
  if (!dryingInProgress) {
    lcd.setCursor(0, 1);
    lcd.print("Dry in progress");
    startTime = millis();  // Start the drying timer
    dryingInProgress = true;
  } else {
    unsigned long currentTime = millis();
    unsigned long elapsedTime = currentTime - startTime;

    // Check if the drying time is reached
    if (elapsedTime >= dryingTimeLow * 3600000) {
      lcd.setCursor(0, 1);
      lcd.print("Drying complete");
      dryingInProgress = false;
      delay(2000);
      break;
    } else {
      // Display remaining drying time in hours and minutes
      lcd.setCursor(0, 1);
      lcd.print("Drying: ");
      int remainingHours = dryingTimeLow - (elapsedTime / 3600000);
      int remainingMinutes = 60 - ((elapsedTime % 3600000) / 60000);
      lcd.print(remainingHours);
      lcd.print("h ");
      lcd.print(remainingMinutes);
      lcd.print("m ");
    }
  }
} else if (temperature >= 28 && temperature <= 32) {
  if (!dryingInProgress) {
    lcd.setCursor(0, 1);
```

```
    lcd.print("Dry in progress");
    startTime = millis();  // Start the drying timer
    dryingInProgress = true;
  } else {
    unsigned long currentTime = millis();
    unsigned long elapsedTime = currentTime - startTime;

    // Check if the drying time is reached
    if (elapsedTime >= dryingTimeMiddle * 3600000) {
      lcd.setCursor(0, 1);
      lcd.print("Drying complete");
      dryingInProgress = false;
      delay(2000);
      break;
    } else {
      // Display remaining drying time in hours and minutes
      lcd.setCursor(0, 1);
      lcd.print("Drying: ");
      int remainingHours = dryingTimeMiddle - (elapsedTime / 3600000);
      int remainingMinutes = 60 - ((elapsedTime % 3600000) / 60000);
      lcd.print(remainingHours);
      lcd.print("h ");
      lcd.print(remainingMinutes);
      lcd.print("m ");
    }
  }
} else if (temperature >= 33 && temperature <= 36) {
  if (!dryingInProgress) {
    lcd.setCursor(0, 1);
    lcd.print("Dry in progress");
    startTime = millis();  // Start the drying timer
    dryingInProgress = true;
  } else {
    unsigned long currentTime = millis();
    unsigned long elapsedTime = currentTime - startTime;

    // Check if the drying time is reached
    if (elapsedTime >= dryingTimeHigh * 3600000) {
      lcd.setCursor(0, 1);
      lcd.print("Drying complete");
      dryingInProgress = false;
      delay(2000);
      break;
    } else {
      // Display remaining drying time in hours and minutes
      lcd.setCursor(0, 1);
      lcd.print("Drying: ");
      int remainingHours = dryingTimeHigh - (elapsedTime / 3600000);
      int remainingMinutes = 60 - ((elapsedTime % 3600000) / 60000);
      lcd.print(remainingHours);
```

```
          lcd.print("h ");
          lcd.print(remainingMinutes);
          lcd.print("m ");
        }
      }
    } else {
      // Reset the drying state if the temperature is not in the specified range
      dryingInProgress = false;
      lcd.setCursor(0, 1);
      lcd.print("Drying stopped");
      delay(2000);
      break;
    }

    delay(1000); // Update every 1 second
  }
 }
}
}
```

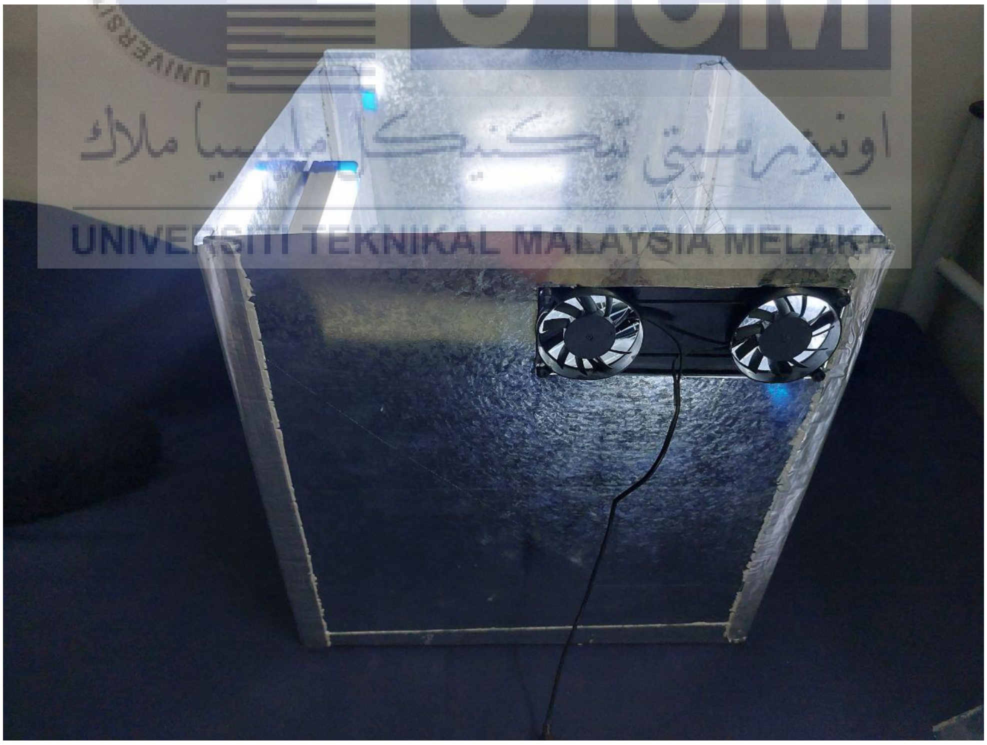
Appendix C Hardware



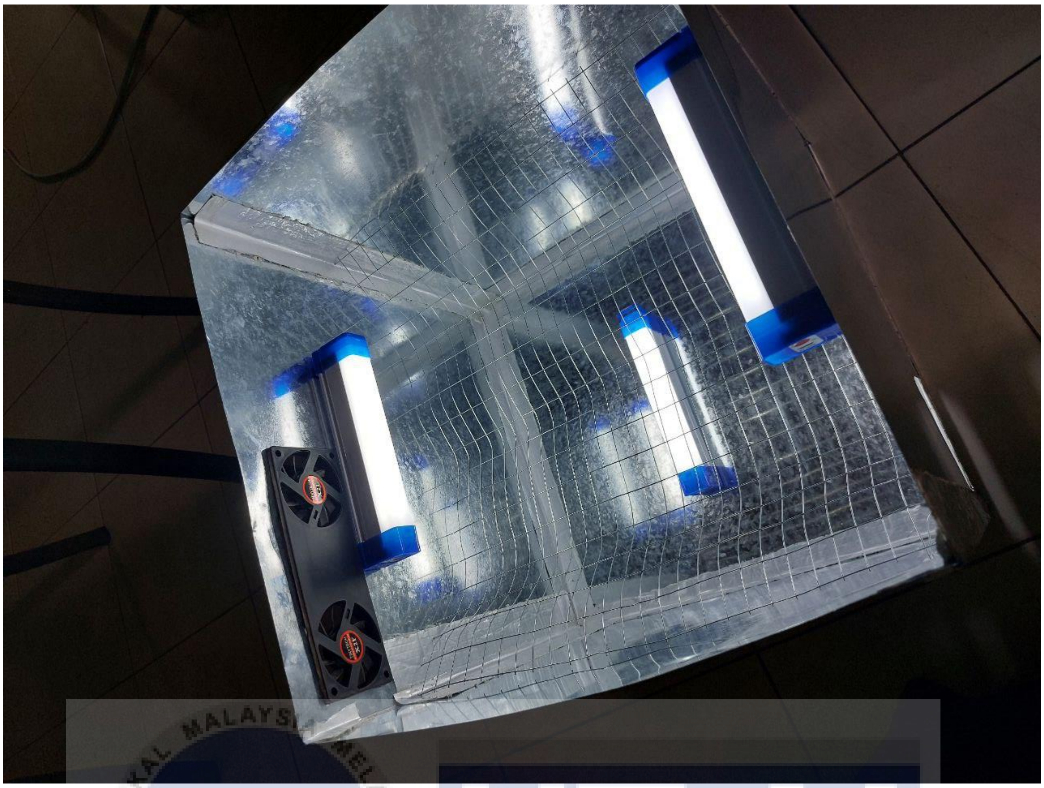
The process of making the box for drying mechanism

The process of taking the drying time

Front view of the Drying Box



Back view of the Drying Box



Top view of the Drying Box