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Monitoring and Controlling the Infestation of Sitophilus Oryzae

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ABSTRACT

Infestation of *Sitophilus oryzae* is considered to be an environmental damage affecting main source of energy in the Philippines which is the rice grain products. Monitoring and controlling the infestation is the most sustainable method to avoid environmental and agricultural loss of grain products. Researchers integrate a technology that focuses on monitoring and controlling the infestation of *Sitophilus oryzae*. U-type tubular heating element is attach to the prototype along with a thermostat control switch to provide a specific amount of heat that is comparable to the heat index of the sunlight as heat is the most favorable way of avoiding and controlling the infestation. There is a webcam installed by the researchers to have a real-time point of view of how the *Sitophilus oryzae* are moving themselves during the process. Researchers provide an SMS notification once a *Sitophilus oryzae* is detected in the prototype. The system is purposefully conceptualized so that it can be used in different types of rice, grain, and other wheat products. Researchers provide this system to maintain the good condition of rice and wheat products, especially for those who have large stocks of them, like farmers and store owners.

CHAPTER I
THE PROBLEM AND ITS BACKGROUND
1.1 INTRODUCTION

Rice, wheat, grain, and feeds are one of the primary essentials supplies in a commercial business here in the Philippines. However, grain damages due to pest infestation is a problem specially for those who have a large amount of stocks of rice grains. Study by Castilla et al (2021) stated that pest surveillance system is necessary for staple foods in order to secure food security in the face of continuous rising of population. In this action, implementation of pest management can contribute to a lower yield loss.

Pest control is a traditional way of controlling the infestation. *Sitophilus oryzae* is the greatest threat to the rice and other wheat grain products time after time. A report in 2018 stated that 330, 300 sacks of imported mills were infested by a specific species *Sitophilus oryzae* and due its infestation, an estimated of 10-40% of the annual worldwide mass production of grains was reported as the overall damage of these grains. To control the infestation, insecticides and fumigation with the registered chemicals such as phosphine and methyl bromide are used as pest control to this species, *Sitophilus oryzae*.

1.2 BACKGROUND OF THE STUDY

Nowadays, store owner are currently dealing with loss of total income as well as decrease in good stocks and grains. Heat control is favorable against grain insects and pests such as the S. Oryzae that can develop internally inside the grains. 40-50°C are considered lethal to these stored-grain insects. The extreme heat of 120° F can kill all life stages of weevil for one hour. Other studies and research conducted using gamma-ray radiation were applied to define the morality of the S. Oryzae. An eco-friendly control method, but it

can cost a lot of money for small store owner. Some fumigation and insecticides to control and contain these pests, but overdoses of chemicals and incorrect use of these may harm the total quality of the grains and feed stocks. The researchers approach the idea of monitoring and controlling the infestation the Sitophilus oryzae in an ergonomic and convenient way for the pet shop and small-time store owner.

Our proposed study on "Monitoring and Controlling the Infestation of the *Sitophilus oryzae*" aims to develop an intelligent monitoring and controlling system to detect, prevent, and obliterate *Sitophilus oryzae*. The system would integrate the existing traditional way of pest control which is putting the rice grains in a flat surface and spread out to expose on direct sunlight. This approach would lessen to the intact outdoors and can be done indoors even with a cold weather.

1.3 STATEMENT OF THE PROBLEM

This study seeks to prevent the infestation of "*Sitophilus Oryzae*" in Jam's Rice and Feed store at Calamba City by a monitoring and infestation prevention system

Specifically, this study aims to answer these questions:

- How to preserve a good quality of rice, wheat, and feed grains in Jam's store?
- How can the system be effective in terms of efficiency, durability, functionality, and reliability in prevention of the infestation of "*Sitophilus oryzae*" at Jam's store?

1.4 OBJECTIVES OF THE STUDY

The general objective of this study is to design a prototype that would monitor and control the infestation of *S. Oryzae*.

This project aimed to achieve the following specific objectives:

- To test the prototype in terms of:
  Reliability, Functionality, and Durability to its temperature and detecting "*S. Oryzae"*
- To illustrate the effectiveness of heat as a pest control of *Sitophilus oryzae*

1.5 SIGNIFICANCE OF THE STUDY

Below is a list of significant contributions of the study.

- To the consumers, the results of this study will contribute to the consumers, and small convenient store owners that supplies feeds, and rice grains.
- To the store owners, the results of this study will be beneficial to the store owners and suppliers which can increase the rate of supply and demand.
- To the community, the results of this study will help the environmental places from the infestation of S. Oryzae.
- To the future researcher, this will be serve as basis or reference for their future research. This study will provide ideas to the researchers and is free for improvements and innovations.

1.6 SCOPE AND DELIMITATION

This study integrates a monitoring and controlling system to prevent the infestation of *Sitophilus oryzae* at Jam's Feed Store. It monitors the appearance of the *Sitophilus oryzae* in the stocks to preserve good quality of grains. It consists of attachment of a heating element that is comparable to the heat index of sunlight that ranges from 30°C to 110°C. With this heat, it can kill *Sitophilus oryzae* from hours to minutes depending on the heat produce.

In addition, it did not extend to monitor a multi container in the store, the prototype is limited to minimum of 3 kg, and maximum is 5-kilograms storage of grains and can't monitor the black rice.

1.7 CONCEPTUAL FRAMEWORK

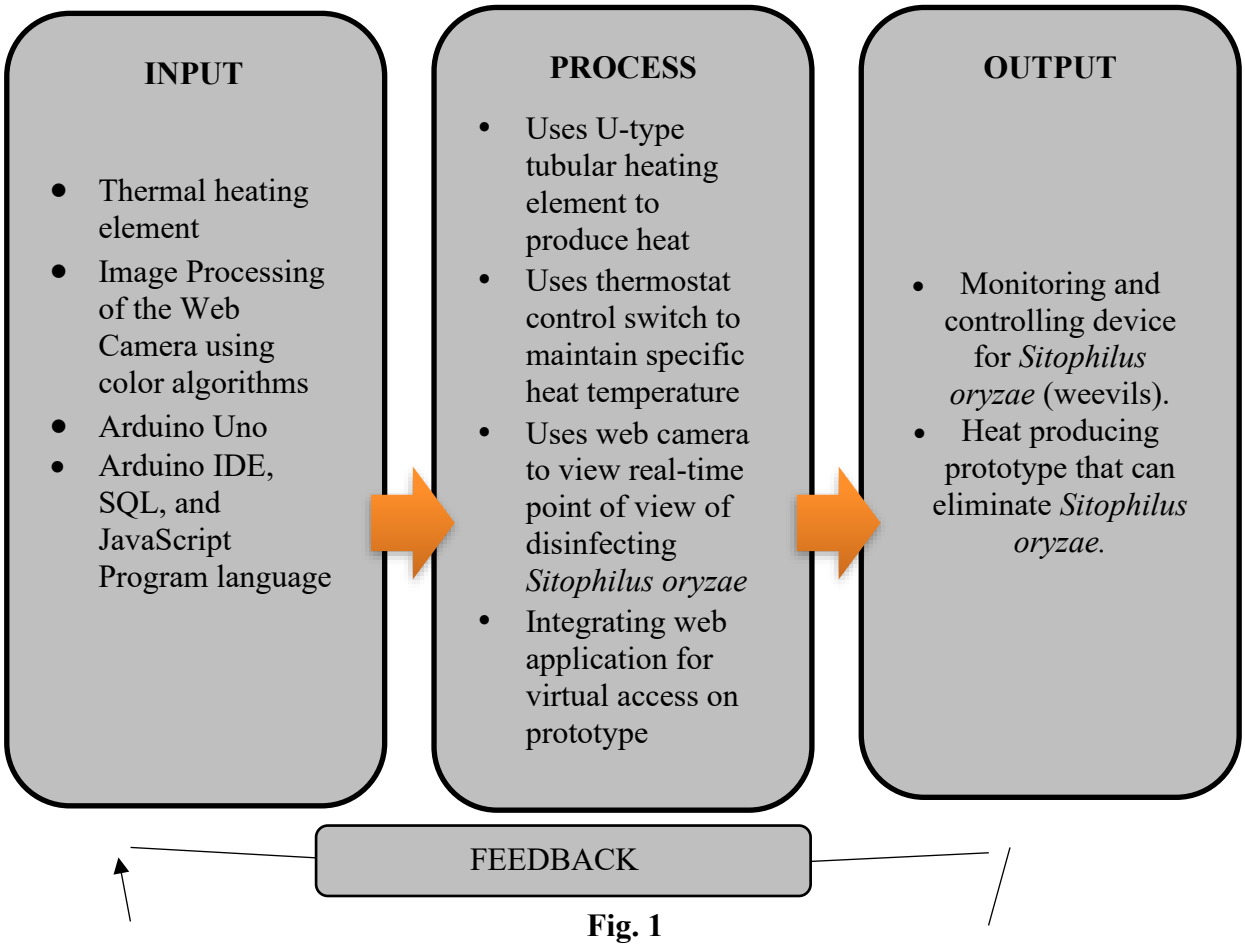


Fig. 1

The input phase includes the materials and tools to be needed to develop a monitoring and controlling system using Arduino, U-type heating element, thermostat control switch and a web camera. The software utilized by xampp application for *Sitophilus oryzae* detection.

The process phase explains how we will integrate the system. Building the prototype to its hardware and software requirements including attachment of the u-type heating element and web camera as its main purpose is to produce heat and detect the infestation of *Sitophilus oryzae*. Creating a web application whereas can access the control of the prototype and serve as a screen monitor on how the web camera detects *Sitophilus oryzae*. With image processing, when *Sitophilus oryzae* is detected, an SMS notification will be send to the user for alert notification.

The output phase elaborates on how the system works and completed. Producing heat prototype will be its main function to obliterate *Sitophilus oryzae* and avoid infestation. It will discuss how the heat treatment is really effective in controlling the infestation. Also, alignment of web camera and web application to provide ease of monitoring to have a point of view the behavior of *Sitophilus oryzae* on heat treatment.

1.8 OPERATIONAL DEFINITION OF TERMS

- Accuracy – a degree of closeness between measurement and its true value
- Arduino Uno – a low cost, flexible, and ease to use programmable open-source microcontroller board that can be integrated into a variety of electronic projects

- Durability – the ability of a physical product to remain functional without requiring excessive maintenance on repair when faced with the challenge of normal operation over its design failure
- GSM Module – for notification systems
- Jam's Rice and Feed Store – a commercial store that supplies rice and feeds, also this is a store that experienced a *Sitophilus oryzae* infestation
- Reliability – is the probability that the system will perform its intended function for specified time period when operation under normal or stated environmental conditions.
- *Sitophilus oryzae* – a pest species that attack grain seeds, such as wheat, rice, and feed grains.
- SQL (Structured Query Language) – is a programming language for storing and processing information in a relational database
- Thermostat control switch – used in temperature control systems to regulate air or liquids and can be used both commercial and domestic applications.
- Power supply – is an electrical device that supplies electric power to an electrical load

CHAPTER II
REVIEW OF RELATED LITERATURES AND STUDIES

This chapter is designed to identify and enumerate several researches related to the present study. The purpose of this review is to set the current research project within a conceptual and theoretical context. This includes a number of citations from magazines, journals, newspapers, case studies, theses, research papers and other reliable literature sources. This chapter highlights local literatures, foreign literatures, local studies and foreign studies.

2.1 LOCAL RELATED LITERATURE AND STUDIES

According to 2018 news on Rappler, a rice imported by the National Food Authority are infested with *Sitophilus oryzae* or "bukbok". The reports Causes an alarm to the Rice consumers. An Entomologist and Global Forum on Agricultural Research awardee explains about this *Sitophilus oryzae* and there are two types of this rice pest insects that Filipinos refer to it. Entomologist said that, in general, these are rice weevils and beetles. Weevils lay eggs in the rice grains and the larvae grows inside. She also added that "they appear not necessarily on old stock, but poorly-stored stock" *Sitophilus oryzae* appears to dried products like corn, flour and rice if it's unattended within days. The entomologist advices fumigation to the infested food because of weevils rapid to reproduce.

In summary, the news about imported Rice by National Food Authority is infested with weevils raises an alarm to the consumers. Entomologist recommends fumigation instead of heat treatment that kills even larva that inside the grains which our project is focused on, preventing the cycle to continue from rice degradation.

A 2022 study by Fawki et. al. about the heat disinfestation as ideal and effective option to eliminate grain pests. the study is focused on using solar radiation to achieve an ideal high mortality rate of *Sitophilus oryzae* including its larval stage that has a significant impact on grain weight loss, subsequent insect infestation, and fungal development. According to several investigations, 100% death of *Sitophilus oryzae* adults occurred within days to hours at 40-48°C, hours to minutes at 48-55° C, and minutes to seconds at 55-66° C.

In summary, the study and our project both utilizes heat as an effective and safe disinfestation for grain products, this alternative of pest control shows a good result which our project focused on improving, and adding features or system further advances and improve the usefulness of such method.

According to 2018 news from The Philippine Star, 100,000 sacks of rice imported by the NFA sat infested with weevils in warehouses at the Subic Bay Freeport Zone, with commercial rice prices reaching up to P70 per kilo in Zamboanga City due to tight supply, low-income households were desperately seeking the cheapest rice from the National Food Authority. NFA officials attributed the weevil infestation to the weather. They explained that the rice, imported from Thailand, arrived earlier this month, but inclement weather delayed the immediate offloading of the shipment. Also stating that such infestation issues are common during the rainy season. Facilities could protect large quantities of rice from weather-related factors that promote fungal growth and insect infestations with improved warehousing. If weevil infestations are seasonal and common, shouldn't the NFA have implemented measures long ago to address the issue? Accelerating the offloading and distribution of the rice could have prevented much of the shipment from being infested. Given the grain's vulnerability to spoilage, improved measures can be implemented to protect rice stocks. However, this isn't the first instance of NFA rice spoiling while in storage. Rice in sacks can endure rough handling but is susceptible to mold and weevils during storage. Poorly maintained rice warehouses are also prone to rodent infestations. Weevils can be eliminated through fumigation, and the rice can be cleaned for distribution, according to the NFA. However, both the infestation and the fumigation process are likely to impact the quality of the grain for consumption. With rice prices soaring and people waiting in long lines just to purchase two kilos of affordable price per household, the spoilage of 100,000 sacks of rice is indefensible. The spoilage not only exacerbates the limited supply of rice accessible to the poorest households but also wastes valuable public funds.
In summary, the Philippine country relies on rice imports to rich the needed amount for the consumers. During transport and while being store, the rice suffers from infestation specially during rainy season. The National Food Authority suggested fumigation to eliminate the pests. However, both the infestation and the fumigation process are likely to impact the quality of the grain for consumption.

According to 2020 news on Cebu Daily News, Displaced tourism workers refused to claim rice assistance from the provincial government due to moldy smells and weevil infestations in Loboc town, Bohol. Goods where left unclaimed in the Loboc Tourism Building including 180 packs of rice and each are containing 10 kilos. The mayor noted that the intended beneficiaries were the town's 1,076 tourism workers affected by the COVID-19 pandemic. Despite the bad smell, some residents have no choice but to feed it to the animals or consuming it, although provincial social welfare officer insisted the rice was in good condition when distributed, Governor suggested spoilage occurred due to prolonged storage by the municipal government. Mayor expressed disappointment over the poor-quality rice. Similar issues with weevil-infested rice occurred in Loon town in 2018, with investigations indicating the infested rice came from the PSWD buffer stock managed by provincial social welfare officer.
According to the 2020 news, A Barangay village chief was unaware that the supplier had delivered tainted rice, expressed regret to the villagers. The chief apologized after distributing rice packs infested with weevils and white worms. Tensions build up between the rice dealer and barangay officials. Additionally, some residents reported seeing lice and mold in the bags, which also smelled bad, with each 25-kilo per sack.
In summary, both the news about people refusing rice as rice assistance from their local government, due to being already spoiled and infested. Spoilage occurred due to prolonged storage. Storing rice for an extended time requires scheduled storage inspection and disinfestation, with proper maintenance and disinfestation some of the infested rice contains rice grains that can still be recover.

A 2021 study by Manalo et. al. examined the extensive 21-day media coverage of weevil-infested rice in the Philippines, a notable deviation from the usual underreporting of agricultural issues. The research, based on a descriptive content analysis of 49 stories from ten Philippine newspapers and data from Media Meter (commissioned by PhilRice), involved insights from five journalists about editorial decisions. Utilizing the hoopla effect theory, along with gatekeeping and social risk amplification concepts, the study highlighted significant implications of the media coverage on the *Sitophilus oryzae* infested rice issue.

In summary, this intriguing media behavior, where the Philippine mainstream media extensively covered the issue of weevil-infested rice for many days, uncommon for local agricultural news. This focus suggests that certain agricultural issues, when framed effectively, can capture prolonged media attention and public concern. The application of theories like the hoopla effect and gatekeeping underscores the complex dynamics of media coverage and its impact on public perception. This study underscores the power of media in shaping discourse around agricultural problems and potentially influencing policy and public awareness.

According to the *study in 2019* by Liwayway. In September 2018, 132,400 bags of rice from Thailand and Vietnam were found infested with weevils in Subic port Philippines. The heat inside the ship allowed weevil eggs to hatch. Indigenous plant-based insecticides are becoming popular over commercial ones due to the damage caused by these pests. The rice weevil, a small, dark brown pest, destroys rice grains, affecting their nutritional value, germination, weight, and commercial value. The use of herbal plant-based insecticides is becoming popular due to its environmental benefits. The Jackfruit peels can be used as an insecticide for rice weevils, as they are less potent to humans. A study showed that jackfruit peel, macerated in 70% ethanol, can kill rice weevils within 20 minutes, with more potency at 40 minutes' exposure. Further research is needed on other insect pests. The JPEE preparation method involves drying ripe jackfruit peel, grinding it, macerating it to solvent (70% Ethanol), filtering it, and subjecting it to rotary evaporation to remove the ethanol, following a 1:4 w/v ratio. This study investigates the effectiveness of Jackfruit Peel Ethanol Extract (JPEE) as an insecticide against rice weevils, a pest that damages rice grain quality and market value. The experiment involved four treatments and twenty rice weevil samples/treatments.

The results showed that the highest mortality rate was observed in T3 (750% of JPEE), indicating that JPEE can be a potential insecticide for controlling rice weevils. No significant differences were found among treatments, indicating that JPEE could be a potential insecticide for rice weevils.

Based on the (2019) study. Rice is a primary energy source for Filipinos, but the tropical climate of the Philippines leads to infestations by pests like the rice weevil, which can diminish the grain's quality and value. Sappan, a medicinal tree used by the Visayan people, contains various beneficial compounds and has antioxidant and anthelmintic properties. This study aimed to assess the mortality rate of rice weevils exposed to different concentrations of Sappan seed ethanol extract (SSEE) over 1.5 hours, with observations every 15 minutes. The SSEE was prepared by sun-drying and processing premature Sappan seeds, macerating them in ethanol, and removing the solvent through evaporation. The weevils were exposed to various SSEE concentrations in petri dishes, and their mobility was tested by touching their abdomen with a glass rod. Mortality was recorded as the absence of movement, and data were collected every 15 minutes. The study aimed to describe the weevils' behavior and determine significant differences in mortality across different SSEE concentrations.

In summary, both studies underscore the potential of indigenous plant-based insecticides in controlling rice weevils. while both studies focused on rice weevils, the findings suggest that further research could

explore the effectiveness of these plant-based extracts against other insect pests. These plant-based insecticides like Jackfruit Peel Ethanol Extract and Sappan Seed Ethanol Extract offer promising, eco-friendly solutions for managing rice weevil infestations. By leveraging locally available resources, these methods not only provide effective pest control but further research could expand on these findings to optimize application methods and explore the efficacy of other plant-based insecticides.

According to the (2019) study by Braza et. Al. This study investigates the dynamic behavior of the rice weevil tyramine receptor, SoTyrR, with or without an agonist ligand. The research aims to correlate intradomain dynamics of SoTyrR to understand the early effects of tyramine and amitraz binding to tyramine receptor activation, a first attempt to understand the role of GPCRs in cell signaling and physiological functions. GPCRs undergo conformational changes after ligand binding, allowing the rearrangement of intracellular domains involved in cellular signaling. The IL3 region plays a crucial role in the activation of GPCRs, as it interacts with the G protein and forms polar and hydrophobic interactions. The stabilization of the IL3 region is highly coupled to the GPCR and G protein coupling, suggesting a highly dynamic nature of IL3. The RMSD of SoTyrR decreases after ligand binding in SoTyR-tyramine, and local fluctuations become more pronounced in amitraz-bound SoTyrR, especially at the IL3 region. Previous structural and conformational dynamics studies of structurally resolved GPCRs agree that IL3 plays a special role in overall dynamics. The study reveals that the stability of SoTyrR and its natural ligand is influenced by the dynamic behavior of the IL3 region. Tyramine, the natural ligand, stabilizes IL3, while TM3 is a key trigger in IL3 conformational rearrangement. The active form of SoTyrR differs significantly from how amitraz activates SoTyrR, with amitraz disrupting IL3 stabilization. Network analysis shows that amitraz takes longer to reach its structural convergence than tyramine, and the IL3 region is influenced by agonist-binding. The 200-ns MD simulations provide insight into the early effects and differences between the two agonists' activation processes.

According to the 2020 study by Ocampo et. Al., Rice weevils are destructive pests that cause significant losses in cereal crops. One safe pest management strategy is using essential oils from plant materials as biopesticides. Moreover, identifying key amino acid residues is crucial for pesticide development. Virtual screening techniques and computational methods like homology modeling and 3DQSAR analysis help understand interactions between ligands and target receptors.

In summary, both studies focus on the rice weevil's tyramine receptor (SoTyrR) and its potential for pest control. these studies highlight the importance of understanding receptor dynamics and ligand interactions for developing innovative pest management strategies. The dynamic behavior insights from the first study can inform the design and optimization of bio-pesticides, as seen in the second study, where computational techniques are used to identify and evaluate effective monoterpene compounds. This integrated approach can lead to the development of targeted and environmentally sustainable solutions for controlling rice weevils and potentially other agricultural pests.

2.2 FOREIGN RELATED LITERATURE AND STUDIES

According to the study of Bjerge, K., Mann, H. M. R., & Høye, T. T. (2021), they used a monitoring with cameras running high frame-rates facilitates the study of individual insect behavior and can improve the accuracy of automatic species classification as several images of the same individual are available for the identification, provided that the individual insects can be correctly tracked between frames. Video monitoring has a high demand for power and storage space and is typically only a viable solution when grid power is available. Furthermore, the footage can be very time consuming to analyze subsequently without automated procedures.

In summary, this research is pertinent to pollination ecology and larger insect monitoring initiatives as it presents a novel approach for automated, real-time monitoring and classification of individually tracked insects. It makes use of readily available technology with the power and storage to keep an eye on insects throughout growing season long. The system includes a deep learning-driven image processing pipeline for tracking and classifying animals. Real-time insect detection and categorization based on collected photos is enabled by using the NVIDIA Jetson Nano running YOLO. This low-cost solution incorporates open-source code and shows how individual tracking improves classification accuracy and lowers biases in abundance estimates caused by seasonal and taxonomic variations in insect residence times on flowers over the course of a growing season.

According to the study of De Sousa I. G. Et. Al. (2023), The two most important indoor infestations for rice that has been stored are Sitophilus oryae and Sitotroga cerealella, which belong to a group of insects that penetrate grains and turn them into flour. S. The two most prevalent species, Oryzae and Sitophilus granarius, are somewhat similar to one another, yet they each have distinct morphological traits and skills. The lengthy snouts of adult rice weevils have sections of their mouths that can be chewed. After fertilising, a female will use her long snout to chew a hole in the kernel and create a tiny cavity, which she then fills with an egg and covers with a gelatinous plug.

Generally speaking, the rice weevil lays more eggs than the granary weevil. When the right circumstances are met, eggs can hatch in a few days, but they can also remain dormant until they are (specifically, temperature and humidity). Under ideal circumstances, the entire transformation from egg to larval, pupa, and adult inside the kernel takes 35 to 40 days, following which the adult chews its way out. The interaction between the rice weevil and rice occurs throughout all phases of the insect's life cycle, with the larvae being the most damaging stage. The rice weevil is one of the most common and harmful insect pests found in stored cereals globally. The hunt for ways to identify and monitor internal (hidden) infestations is more important for the rice processing industry because the grain is normally stored with husk (paddy rice), which protects against exterior pests. The most common approaches for inspecting grain for internal infestation rely on the methods specified in ISO 6339-4:1987, which describes a total of 5 methodologies for assessing the degree of, or detecting, hidden insect infestation. Carbon dioxide production can be determined using the ninhydrin method, whole-grain flotation, acoustic method, or X-ray method.

In summary, the application of these technologies in the rice processing business should be prioritized. In the future, bio-packaging made from rice byproducts, combined with proper pest management measures, should be employed in accordance with circular economy concepts. In addition, a life-cycle evaluation and cost analysis will be required before proposing alternate approaches and bio-packaging for large-scale insect infestation treatment.

According to the study of Wang, J., & Bu, Y. (2022), Information on insect population trends is obtained through an ongoing biomonitoring project and is helpful for pest control. Legislative terrestrial biomonitoring, such as the EU Habitats Directive, focusses on a small number of specific insect species, such as rare butterflies and beetles, because the majority of insect taxa are too difficult or too expensive to monitor. It is critical to develop new insect monitoring approaches based on field samples, such as DNA barcoding and meta barcoding, even if high-throughput systems are currently incapable of providing accurate insect population estimates. Deep learning and computer vision techniques can now be used to enhance or even replace human observation. The use of video traps for vertebrate monitoring has increased significantly over the last decade. Cameras and other sensors are being used to better study the diversity

and abundance of insects. Deep learning has just lately begun to be employed in biodiversity research and invertebrate monitoring, despite widespread interest in other areas.

In summary, since functional parameters like biomass can be used in biomonitoring applications, we believe that deep learning and computer vision can be leveraged to develop state-of-the-art, high-throughput systems for species identification and counting. These methods may help address long-standing concerns in ecology and biodiversity studies as well as contemporary problems with surveillance and monitoring of insect populations.

According to the study of Ahmad R. et. al. (2022), The fundamental cause of stored grain pests' existence is the presence of conditions that promote their development and survival. A wide range of insect pests can access stored grains at several stages of grain processing, including seed production and maturation, threshing yard processing, seed transport, and storage. Certain bugs destroy seeds while they are still growing and even while they are in storage. The primary sources of infection are old storage facilities, bags, and containers. In addition to contaminating food products with a variety of live insects, insect products such as chemical excretions or silk, dead insects, or other storage structures, stored grain pests cause significant post-harvest losses, ranging from around 9% in developed countries to nearly 20% or more in developing countries.

In summary, the majority of these pests belong to the orders *Coleoptera* and *Lepidoptera*, which account for over 60% and 10% of all stored grain pests, respectively. In addition to contaminating grains with their excretory secretions, which can be exceedingly dangerous to human health when processed and infested, stored grain pests primarily cause quality losses rather than quantity. Stored grain pests typically feed on grain, bore into the kernel, damage the germ component, generate heat, and cause degradation in stored grain products. Chemical changes in proteins, carbohydrates, and amino acids cause quality loss in stored grains and reduce their nutritional value.

According to the study of Johnson, J. B. (2020), the only standard method for detection and quantification of insect in stored grains is the FDA-approved floatation method. Additional, traditional techniques include visual inspection, the use of Berlese funnels or other heat-based techniques, detecting probes or traps, kernel staining, and measurements of uric acid or carbon dioxide. Among the previously described methods, near-infrared spectroscopy (NIRS) is particularly noteworthy due to its low cost, dependability, and instantaneous nature in providing details on a sample's chemical makeup. In contrast to other methods, near-infrared spectroscopy is quick, non-destructive, and non-invasive, enabling great throughput. NIRS analysis can be performed in either reflectance or transmittance mode, depending on the sample composition. To put it simply, the equipment emits the full near-infrared spectrum of wavelengths, which penetrates the material. Some wavelengths are absorbed by energizing specific chemical bonds in the sample, while the remainder are transmitted or reflected back to the instrument, resulting in the spectra obtained. Absorption peaks can be used to determine the chemical makeup of a sample. Multivariate data analysis, often known as "chemo metrics," is used to find, examine, and quantify spectral changes between samples. A more comprehensive explanation of NIRS, including a discussion of regularly used data analysis techniques.

In summary, applications for near-infrared spectroscopy (NIRS) are becoming more and more varied. These include the examination of grain and fruit quality, living tissue, wood products, identification and age-grading of insect species, and the provision of taxonomical data. Additionally, NIRS has been used to find infestations in other crops and goods that are kept in storage, like dried and fresh fruits. These applications have already been assessed elsewhere, so they won't be taken into consideration here. This

article attempts to give a broad overview of the applications of near-infrared spectroscopy (NIRS) in the past and present for identifying stored product pests in grains and pulses, as well as the technology's prospects for the future.

According to the study of Thakkar, B. & Parikh, P. (2020), Chemical fumigants and synthetic pesticides are commonly employed to avoid product loss, but continuous usage can result in pest resistance, poor food quality, negative impacts on human health, and environmental difficulties. To tackle pests, insect-specific insecticides necessitate bulk raising and pure breeds in controlled environments. Understanding insect life cycles is critical for effective pest monitoring and management, with research looking into *Sitophilus oryzae* life cycle, food grain type, and agro-climatic conditions. A host choice is critical for an organism's life cycle, as evidenced in the rice weevil *Sitopilus oryzae*.

In summary, the investigation on the raising and host preference of S. oryzae indicates that, of all the cereals studied, maize is the most suitable host for S. Oryzae in laboratory settings. All stages of the life cycle, from egg laying to emergence, were shown to be highest in maize. The study also found that maize was high in carbohydrate, which boosted the size, fertility, and longevity of insects. Hence, maize is the finest suited food for growing S. Oryzae insects.

According to the study of Banga, Km. S. Kumar, S., Kotwaliwale, N., & Mohapatra, D. (2019), About 10% of post-harvest losses in food grains are caused by insects, rodents, micro-organisms, and improper storage. In India, about 14 million tonnes of food grains worth Rs. 7000 crores are lost annually, with insects alone responsible for losses of about Rs. 1300 crores. Post-harvest losses due to storage and insect accounts for 2-4.2%. Insects cause economic losses in terms of consumption and spreading contamination. About 600 species of insects are found in stored grains, with about 100 species causing economic losses. Also, Insects respond to various natural and simulated features, classified into behavioral and metabolic responses. The primary insects bite or pierce intact and stable grains, while secondary insects feed on broken grains, grain dust, and powder left by the primary and secondary insects. These insects can be more destructive than secondary pests, especially in short-term storage of food grains. To prevent insect infestation in stored food grains, maintain low moisture content and temperature. Store cereals below 12% moisture content, pulses 10-12%, and oil seeds 7-9%. Store grains at temperatures below 5°C for mites, 15°C for insects, and 10°C for molds. Bulk storage affects infestation rates, as larger structures may cause more spoilage.

In summary, this study aimed to understand the insect that the behavior and life cycles is crucial for reducing post-harvest losses in stored grains. This knowledge aids in monitoring and assessing insect damage, enabling grain storage handlers to adopt appropriate technology and reduce losses, thereby meeting the increasing population needs.

According to the study of Okpile C, Zakka U, Nwosu LC. (2021), the disinfested grains were stored in a refrigerator for 7 days, then acclimatized at room temperature and humidity for 72 hours. The average moisture content was determined using the standard oven method. Twenty grams of standardized rice grains were introduced into jars, and two pairs of 7-day-old *Sitophilus oryzae* were released. The parent weevils were left for 7 days to feed and lay eggs, and the insects count began 35 days' post-infestation. Seeds and frass weight were measured on the 57th day post-infestation. Moreover, the study found that rice weevil, a common coleopteran insect pest, has economic importance to rice grains stored for 35 days unprotected. None of the brands were resistant to infestation and damage by *Sitophilus oryzae*, with susceptibility varying between brands. Exotic rice brands, which had better post-harvest systems and processing, did not perform better than local rice brands in terms of resistance to *Sitophilus oryzae*. This

suggests that rice brand resistance to weevils is not solely dependent on post-harvest systems but could also be attributed to origin and genetic factors.

In summary, this study aims to identify commercially available rice brands with resistance to *Sitophilus oryzae* infestation, determine if brand difference influences insect body weight at emergence, and determine if infestation rate is related to brand palatability and appearance. Phosphine insecticide is effective, but resistance limits its sustainability. The study aims to address the understudied roles of appearance and palatability in rice brand susceptibility.

According to the study of Getachew, B., Neela S., Solomon W.F., Melaku W., & Minaleshewa A. (2022), in sub-Saharan Africa, food insecurity is a major problem because over a billion more people are expected to join the global population in the next ten years. This expansion is mostly concentrated in underdeveloped nations that already struggle with food instability and hunger. Reducing agricultural production losses could increase food security and assist fulfil the world's food demand. Food security and quality are impacted by insect pests like *Prostephanus truncatus*, which significantly reduces postharvest losses in grains. Postharvest losses caused by insects, especially in maize, are a major problem in Africa. A significant pest, the maize weevil severely reduces the weight and quality of grains.

In summary, the study discussed that the botanical insecticides, such as essential oils, flavonoids, and esters, are a natural alternative to synthetic insecticides. They have various chemical properties and affect insects in various ways. Organic crop producers in industrialized countries recognize botanical insecticides. Raising awareness among farmers is crucial, especially in developing countries. Commercial botanical insecticides should be important in the market, but better understanding of their mode of action, effects, and regulatory issues is needed. Scientific standardization can help raise their profile and contribute to sustainability.

According to the study of Nazmi, H.F. et. al. (2020), In an effort to identify infected palms as soon as possible, alternate techniques for infestation detection are now being investigated. Using trained smelling dogs and keeping an eye on auditory cues linked to RPW larvae munching are two instances. All of the options, nevertheless, had shortcomings, such as low precision or restricted applicability for large-scale plantations. Because of this, the traditional method of identification still depends on identifying the outward signs of RPW infection on palm plants. Well-documented physical signs of infection have led to the classification of RPW infestation stages into five levels according to P. canariensis infestation intensity. Currently, growers' eye inspections are the most trustworthy way of monitoring for RPW infestation detection. But the procedure is frequently drawn out and only becomes apparent once the RPW infestation has gotten really bad. In this investigation, deliberately infected E with RPW. guineensis and then tracked the development of the outward manifestations of infestation as well as the physiological alterations in terms of growth and photosynthetic activity that occurred during the infestation period. The RPW infestation is characterized by internal devastation of host palms, hence any alteration in the physiology of infested palms, such as increased photosynthetic activity, could serve as a valuable indicator of the infestation.

So, in conclusion, RPW larvae caused significant harm to E. guineensis palms within nine weeks of infection, resulting in considerable physical and photosynthetic damage. The physiological alterations were more obvious than the physical damage, and photosynthetic activity decreased in the third week. However, growth, stomatal conductance, and chlorophyll content were unchanged. This proposes a novel strategy for early detection of infested palms, with the potential to incorporate integrated pest control into pest management.

SYNTHESIS

In this chapter, the researchers gathered literatures and studies, which serve as the foundation for a deeper and better understanding of the topics related to the proposed project.

The studies explore postharvest disinfestation treatment protocols for pest control in stored products, focusing on various insect species. The thermal death kinetics of adult rice weevils reveal a 0-order kinetic reaction model with an activation energy of 505 kJ/mol. One promising approach is heat treatment, which involves progressively increasing the temperatures to 120°F- 140°F for a whole day. Moreover, the use of heat treatment, fumigation, and spraying as alternative pest control techniques is highlighted.

As one of the features of the system, it includes a recommended thermal heating element instead of using the solar panel to create heat temperature and image processing. Additionally, the creation of a website is included in the system for real-time viewing.

Given the above-mentioned analysis of the related literature and studies, the researchers concluded that the proposed project entitled “Monitoring the infestation of sitophilus oryzae at Jam’s store” would help the proponent.

CHAPTER III
METHODOLOGY

The research methodology and procedures used in the current study are systematically presented and discussed in this chapter. This includes details of different processes that would be used to develop the design project. Likewise, in this section different developmental phases of the study are shown. Furthermore, thorough discussion of the project’s design and development procedures is included in this chapter. This also contains explanations of the several evaluation and consistency tests that they would undergo to ensure design stability and reliability

This chapter presented the designs, materials, procedures and statistical procedures and analysis used in this study. This will also provide the outlines of the project’s methodology, the research and development method, project design, operation flow, material descriptions, project development, testing and evaluation methods.

3.1 GENERAL METHOD USED

This study used descriptive methods of research in this study to describe, analyze, explain, define, illustrate and describe the existing conditions that helped lessen the errors in this study. Survey is a type of descriptive research, which is on this project.

The researchers also used experimental research methods to enable the researcher to estimate the effect of an experiment treatment. Experimental research can be done in the laboratory, in the class, and in the field. The researchers chose this method to determine the validity of conclusion that can be drawn from the study.

3.2 PROJECT DEVELOPMENT MODEL

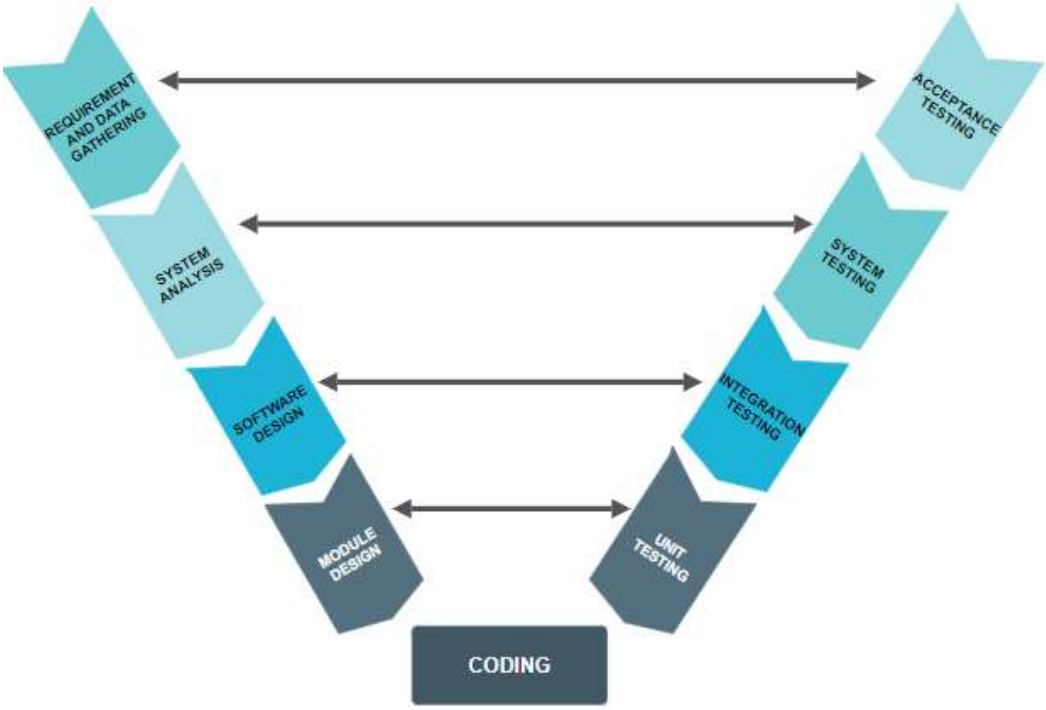


Fig. 3.1 Project development Model

This section presented the processes that used by the researchers in developing the Monitoring and Controlling the Infestation of *Sitophilus oryzae* at Jam's Feed Store. The project undergone to the stages that the researchers needed to do to accomplish the project's objectives. These activities were done to improve the project and to lead the development of the system. The researchers used the V-Model as their project development model. It consists of stages from gathering and analysis of data to determine the specific problem of the study to design phase, coding, and testing. Whereas the module design should meet its requirement from the unit testing. Software design align with the integration testing. And data gathering procedure is answered by the acceptance testing

3.3 DESIGN PHASE

The "Monitoring the infestation of *Sitophilus oryzae* at Jam's Store" used hardware components and software specifications. The researchers used NodeMcu, Arduino Uno, heating element, Web Camera for image processing, LCD screen, temperature sensor, Gsm Module, connecting wire, Power supply, Plywood, and Thermostat Controller. The web application act as monitor and push buttons control in the system. The Node MCU will be powered by a 5v Power supply direct to the 3-gang socket. All the data is received by the Node MCU will transfer the collected data's going to the Arduino UNO via built in GSM Module. The LCD screen will show the timer and temperature of container because it has a heating mechanism at the surface and the 5v battery installed in the Node MCU powers it. The Arduino UNO will gather the data and will send it via GSM module.

3.4 SCHEMATIC DIAGRAM

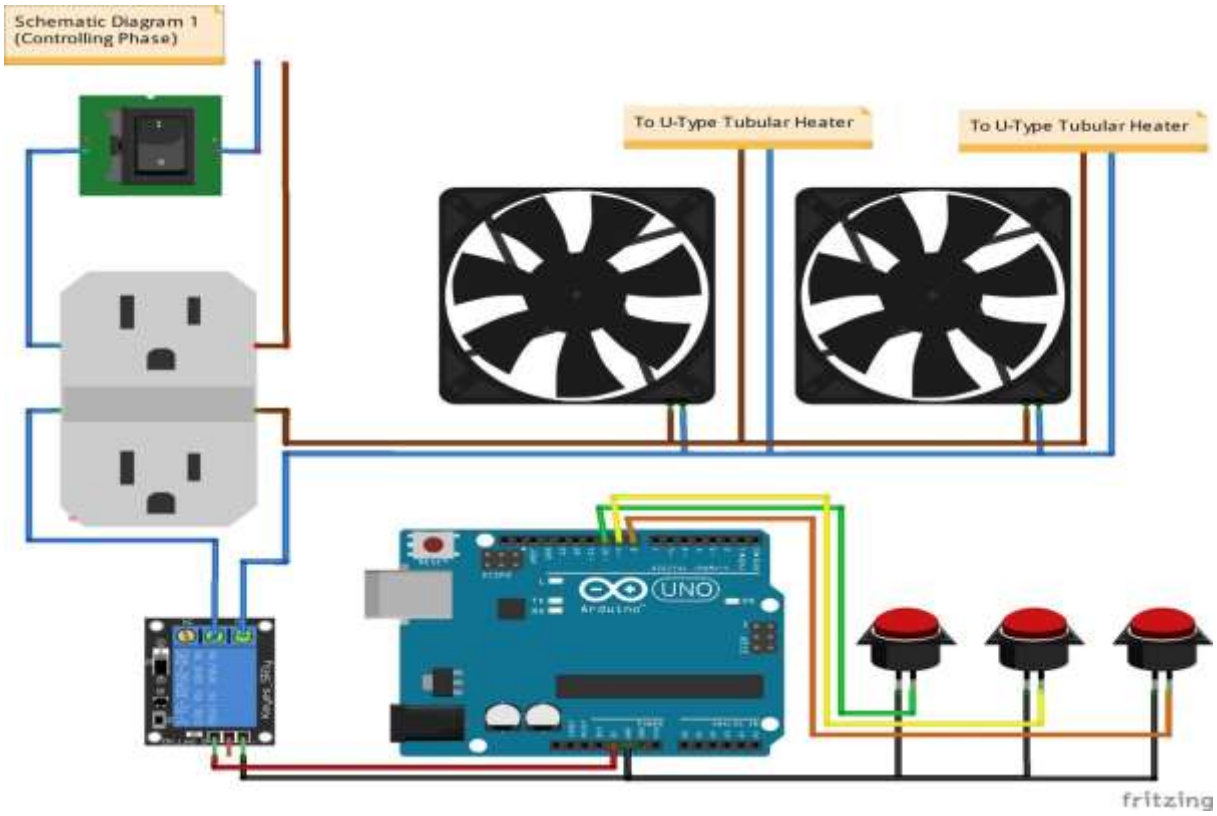


Fig. 3.2

Figure 3.2 shows the schematic diagram of the first integration of the system. It consists of the Arduino Uno, Metal Fan, and U-type Tubular Heater, 5v relay, 4-pin rocker switch, Push buttons and a socket. It functions as the controlling phase whereas the U-type produce a specific heat and the metal fan act as a blower to distribute the specific amount of heat to the subject, which is primary the rice, and wheat products.

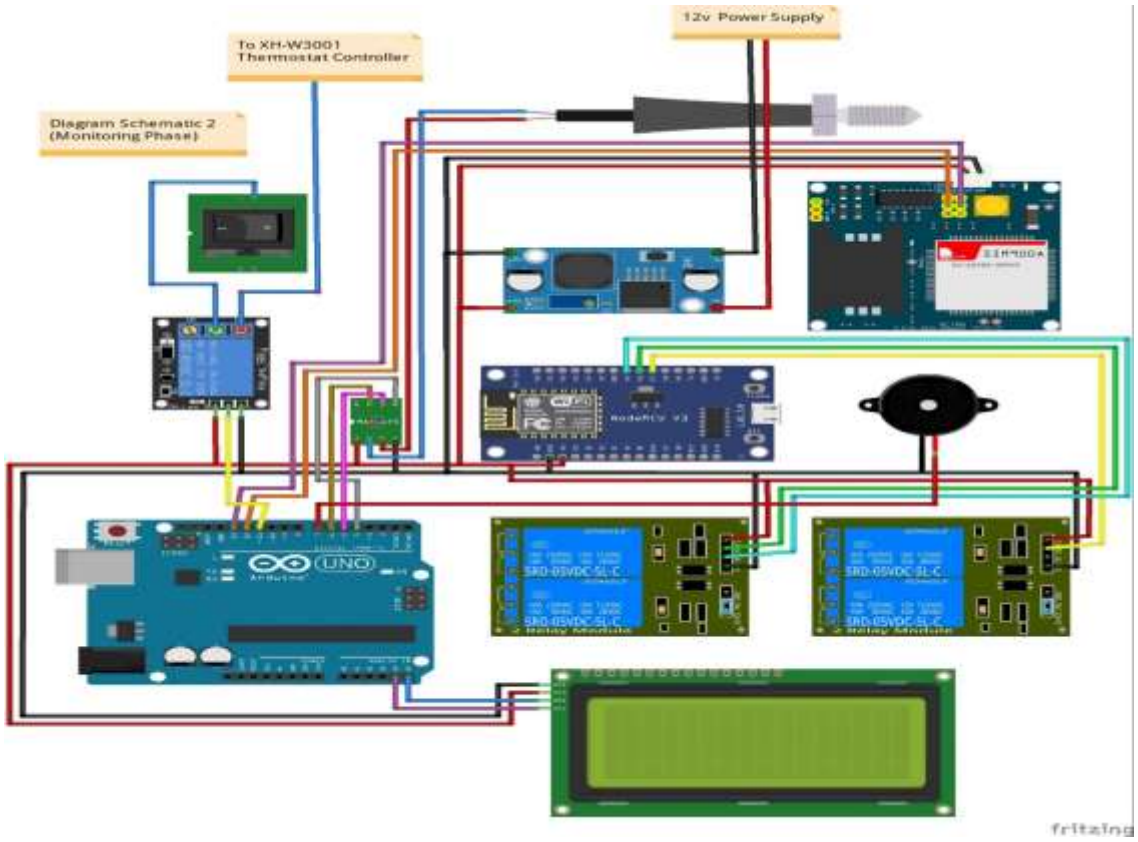


Fig. 3.3

Figure 3.3 shows the schematic diagram of second part of integration. It serves as the monitoring phase of this system. This include as it follows; Arduino Uno, NodeMcu, 12v Power Supply, 5v step down power module, Thermostat Control Switch, Gsm Module, 20 x 4 LCD Screen. Thermocouple K-type sensor, 2 2 channel relay, and a 4 pin rocker switch. It has the sensor where you can monitor and regulate the specific heat index of the system. A NodeMcu that interacts on a database to control the system using web application.

3.5 FABRICATION PHASE

The researchers procured all components and materials needed. The researchers needed to come up with a better solution after procurement process has been finished. After completing it, programmer and researchers needed to collaborate in testing and trial stage using breadboards and connecting wire to test the system.

3.6 EVALUATION PHASE

To ensure the accuracy, durability and reliability of the project, the researchers conducted a self-testing method that made the project functional. To be able to test the prototype, the researchers tried to get 5 kilos of rice and feedstock that already have a S. Oryzae and start the monitoring phase. The monitoring phase should be activated when the Heating mechanism along with the S. Oryzae begun, the NodeMCU will then collect data's from real-time viewing processing, and send it to Arduino UNO with GSM module attached. The Image processing will keep the S. Oryzae is showing in field within the required timer set. If the S. Oryzae was showing up on the webcam while doing a quick monitoring with the timer set around 15 minutes with a temperature of 40-60°C. On the other hand, in the long term of monitoring which is the timer set is around 60 minutes with the temperature is 30-50°C. The Node MCU will send signal to the

Arduino UNO with GSM module to be able the researcher/proponent proceed to Controlling phase by using a web application.

3.7 PROJECT DESIGN

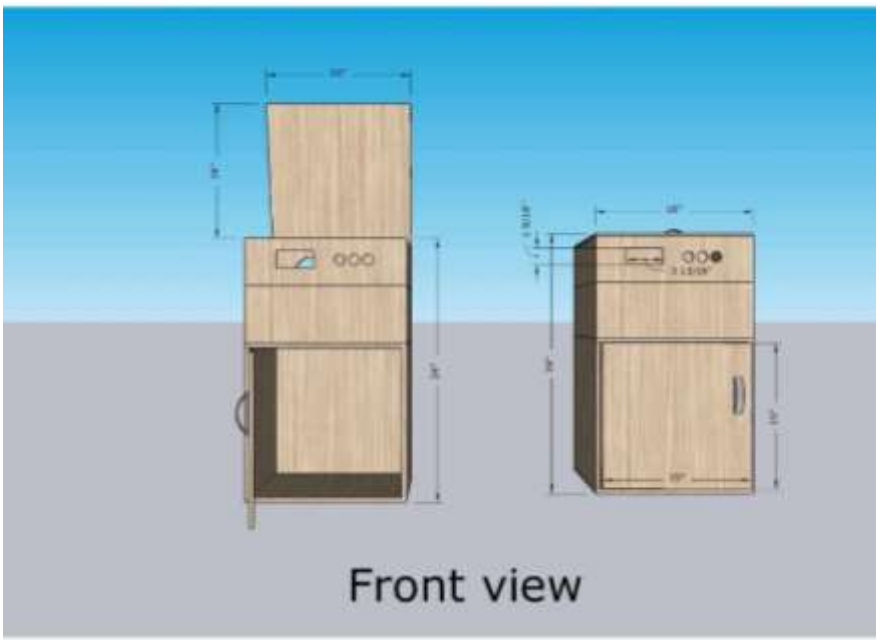


Fig. 3.4

Fig. 3.5

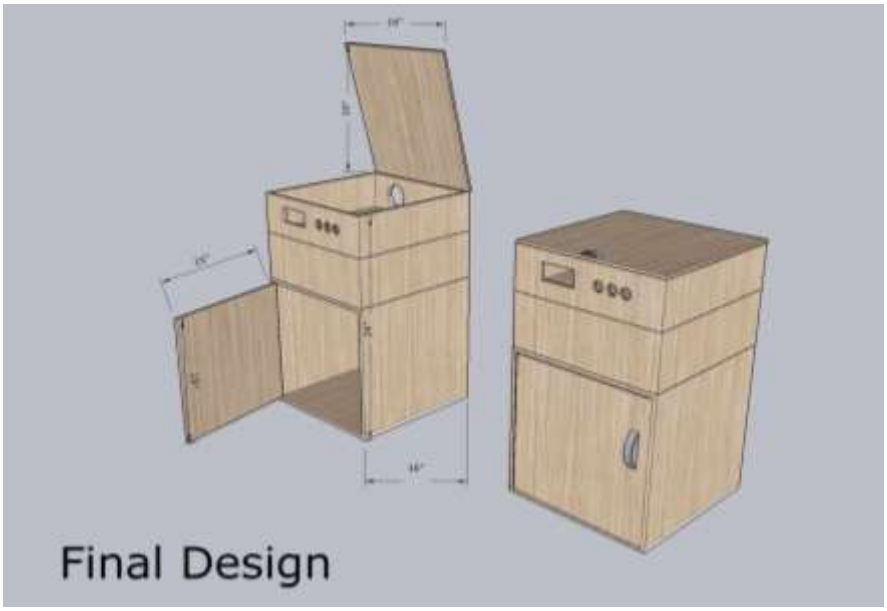


Fig.3.6

The system's general objective is to monitor the infestation of S. Oryzae at store. It can detect if the container of rice and feedstock have a S. Oryzae with the help of heating element that can provide heat from the top. The webcam will act as the image processing that connected to web application and the Node MCU will be the receiver that gather and process all the action's need, installed inside the web application. The system uses built in Wi-Fi/GSM module for wireless communication.

3.8 OPERATION FLOW

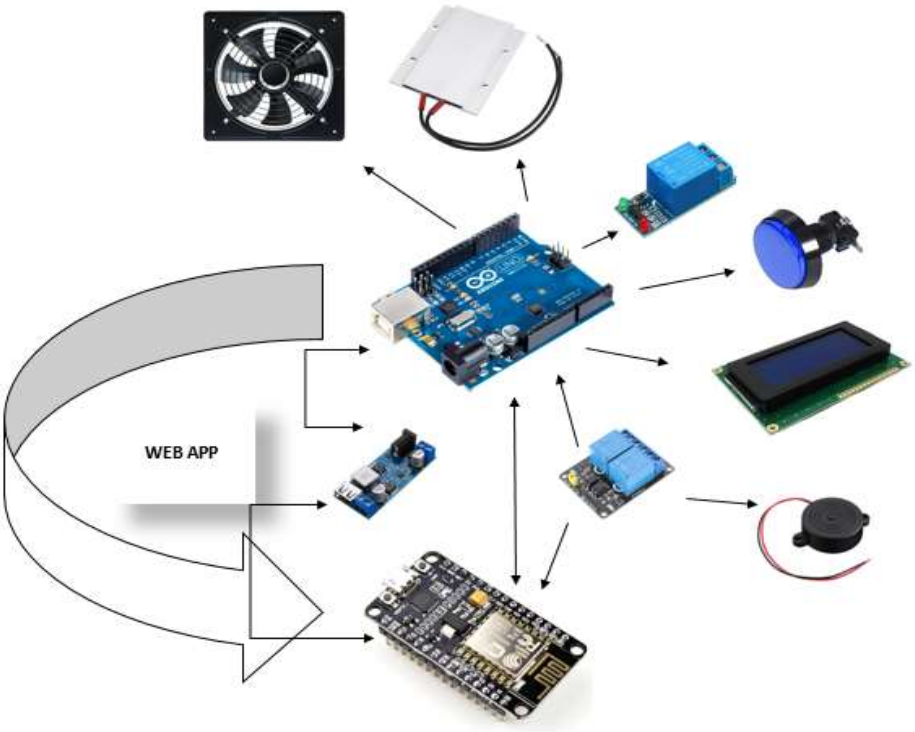


Fig. 3.7

The system uses an NodeMCU with built in Wi-Fi as the transmitter from the S. Oryzae. It is powered by a 5V power supply and installed on the wooden box container. Heating element, image processing, heat temperature, thermocouple Sensor, relay and LCD screen are all connected to Arduino. The microcontroller used in the system is Arduino UNO. It will handle all the process sent by the NodeMCU via Wi-Fi, the data inputs that gathered from image processing. The Arduino UNO is powered by 12v power supply, installed in the container. GSM module is connected for data's output.

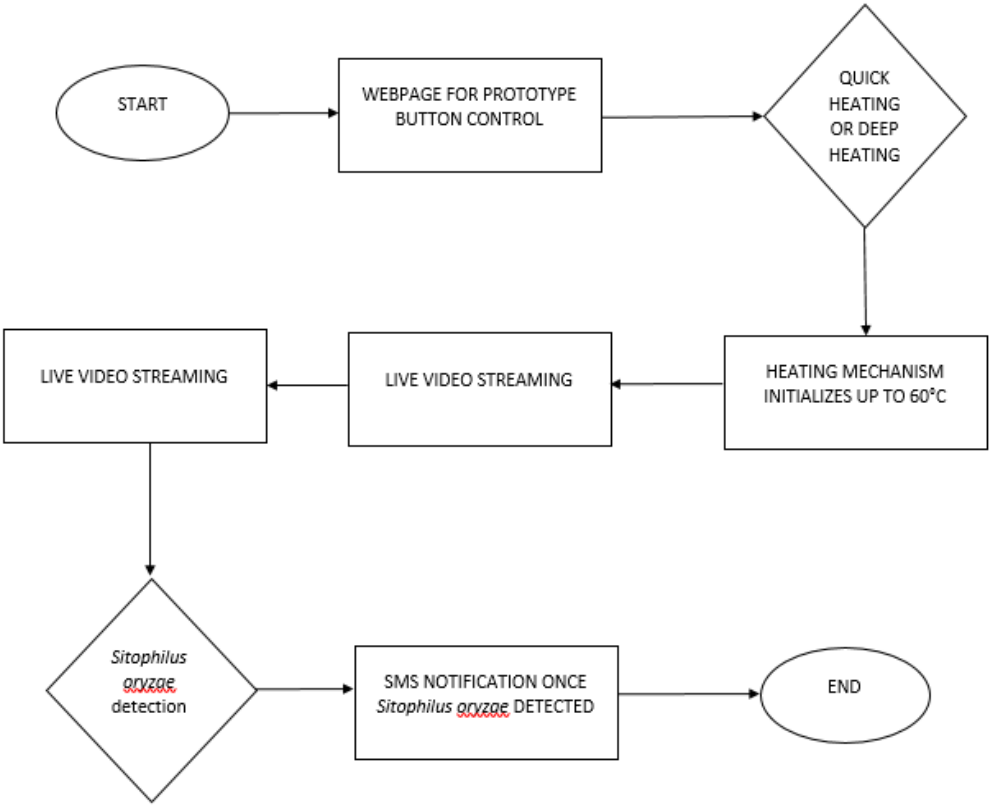


Fig. 3.8

In figure 3.8 it shows the flow of the design project and how it works. The system is very helpful to the proponent store. This will prevent the *Sitophilus oryzae* from infestation of rice or feedstock when monitoring along with the timer and can provide immediate action and response when the device is on. The proponent will receive a message that indicates the device for start and stop processing and a notification every three minutes through the GSM module.

3.9 PROJECT DEVELOPMENT

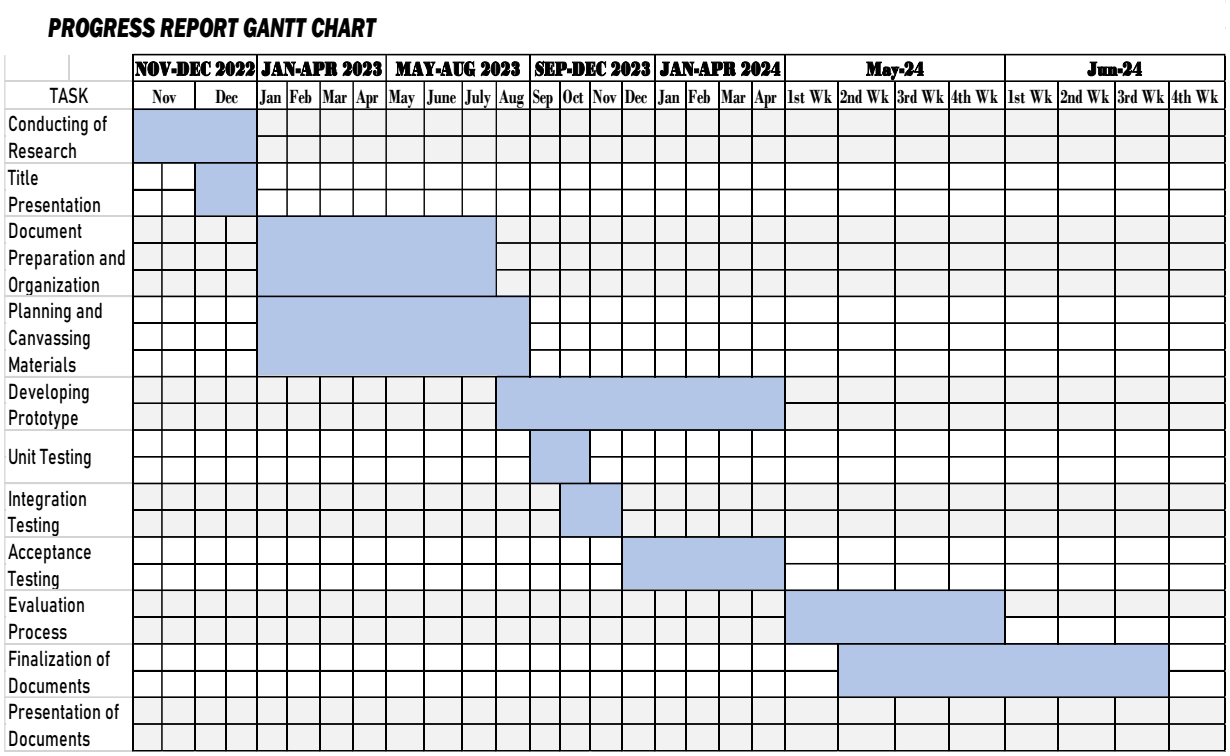


Fig 3.9

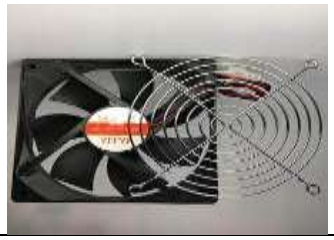
Table shows the timeline progress report on developing and building the prototype. The researchers presented their title on December 23, 2022. Documentation and preparation was made from January to July 2023. Also, preparation and canvassing of materials last until month of August year 2023. After all the components are acquired, the researchers proceed at unit testing on September and October 2023. Researchers started the integration testing on September until November 2023. All components and integration are attached together, acceptance testing starts from November 2023, and last until April 2024. Evaluation period is within the month of May 2023 and finalization of documents last until 3rd week of June 2024.

3.10 DESCRIPTION AND SPECIFICATIONS OF MATERIALS USED

TABLE 3.1: LIST OF ELECTRONIC COMPONENT USED FOR THE PROTOTYPE

Electronic Components	Description
Node Mcu 	- Is an open source software and hardware development and environment that is built around in inexpensive System-on-a-chip (Soc) called the ESP 8266. The term "NodeMCU" refers to the firmware rather than the associated development kits.

 Arduino Uno	- Is an open source microcontroller board based on the microchip ATmega328P microcontroller, developed by Arduino.cc, and initially released in 2010 - The board is equipped with sets of digital and analog input/output pins that may be interfaced to various expansion boards and other circuits
 Heating Element	- U-Type Tubular heating Element are a versatile and economical heat source for a wide variety of industrial and commercial applications.
 Web Camera	- A webcam is a video camera which is designed to record or stream to a computer or computer network
 Gsm Module	- Is a device that uses Gsm mobile telephone technology to provide a wireless data link to a network.
K-  Thermocoupe Type Sensor	- Is a sensor that measures temperatures. It consists of two different types of metals that joined to one end.
 Max6675 Module	- It is a sophisticated Thermocouple to digital converter with a built in 12 analog to digital converter.
 Thermostat Controller	- Thermostat is used to set a specific temperature whereas it can automatically switched on and off when desired temperature is obtained.

 LCD 4x20 Screen	- a screen display that can display 20 characters per line and there are four (4) such lines.
 Rocker Switch	- A four (4) pin switch has four terminal or pins for connection in a project circuit.
 Push Button	- Push button is an electronic component whereas used to control an electric circuit or to control some aspect of a machine or process.
 Blower Fan	- is a device which increases the velocity of air when it passed through its propellers.
 Plywood / Ply Board	- Plywood is wood veneers bonded together to produce a flat sheet.
 Powe Supply	- It is a device providing power to electronic equipment and sometimes designated A, B, or C according to its function of heating vacuum tubes cathodes, causing a flow of electron current in plate circuits, or applying a direct voltage in grid circuits
Pins  Connector	- It is represented as a straight line. - It is usually made of copper and is provided with insulation to make electrical connection between two points

 12v to 5v DC-DC Converter	- a module that converts 12v DC to 5v DC
 Relay Module	- a relay modulefunction is mainly switch electrical devices or system on and off

Table 3.1 specifies the electronic equipment used in the Monitoring of *Sitophilus Oryzae* at Jam's Store. It includes the equipment image, product description and its function or purpose in the system.

TABLE 3.2: BILL OF MATERIALS

Bills of Materials			
Product Name	Unit Price	Quantity	Total Price
Node Mcu esp 8266	399.75	1	399.75
Arduino UNO	499	1	499
U-Type Tubular Heating Element	418	2	836
Web Camera	1500	1	1500
LCD Screen	120	1	120
Thermocouple K-type Sensor	105	1	105
GSM Module	439	1	439
240vac Metal Fan	140	2	280
Wood	300	2	600
Thermostat Control Switch	150	1	150
Push Buttons	50	3	150
Bracket for U-type tubular heating element	50	2	100
Total Cost			5178.75

(eq. 1)

Total project cost

Materials cost + labor cost + other expenses = P 5178.75 + P 5,000 + P 5,000 = P 15,178.75

The table 3.1 presents the overall material cost of the proposed system spent for its development.

3.11 TESTING METHODS

The researchers conducted a self-testing method to test the project if it is operating and functional. To be able to test the system, the researchers tried the monitoring device that placed in a wooden box container. With the help of heat from heating element, the S. Oryzae was able to show up. And at same time the researchers tried to put a timer which is, if the user wants a quick monitoring, they can set the time at thirty minutes and if they want a long term, it can set at 1 hour and after the timer was finished, it's automatically shut down or off to cool down the device. This is to determine how effective does heat temperature can control *Sitophilus. oryzae* from its infestation. By monitoring, the researchers tried to put a webcam which is attached to Arduino Uno and connected to web server that will serve to real-time viewing the oryzae. The system will notice the *Sitophilus oryzae*, take an immediate action, and notify the user stating that the *Sitophilus o*ryzae has been capturing from the container.

3.12 EVALUATION AND IMPLEMENTATION

To be able to check the quality and consistency of the system, the researchers needed an evaluation process. This process helped them determine the weakness of the system. They gave an evaluation sheet to evaluate the project system. The researchers presented first their project before the evaluation. To determine the weakness and functionality of the device, the researchers conducted evaluation from the following respondents:

A. Owner of the feed/food's Store
B. Rice Store
C. Farmer
D. Student

Evaluation Criteria

The criteria that the researchers observed and considered during the evaluation of the system are shown below:

***TABLE 3.3:* Criteria for System Evaluation**

Criteria	*Indicator*
Functionality	*The proposed system works properly and all expected outcome are delivered *The system are user-friendly and has met the requirements of the user
Reliability	*The proposed system can be used in any time and place with minimal or without consequences in its functionality. *The system perform with minimal or without error during its operation
Durability	*The proposed system requires only minimal maintenance after its operation. *The integrated device are carefully placed inside the briefcase and system is in rugged construction.
Extensibility	*The system supports adaptability, coping with the needs of the end-users *The system can still be integrated with the other devices in the future
Economic Feasibility	*The proposed system offers long term usage and can be considered as a good investment *The total cost of the system is a practically worth of its performance

3.13 TESTING PROCEDURE

Testing a prototype design is a very important part of the design and manufacturing process. Testing and evaluation, simply confirms that the product will work as it is supposed to, or if it needs refinements. Testing ensures that any user instructions can be worked out, stage by stage, so that the future consumer can use the product efficiently and safely.

3.14 INSTRUMENT AND TECHNIQUE USED

In gathering data, the researchers administer interviews to the respondents through messenger chat and personal interviews. The proponents will use the survey method.

A. Unit Test

Unit test establishes that a system module performs a single unit of functionality to a prescribed specification. It is a test of functionality of a system module in isolation.

TABLE 3.4: UNIT TEST OF MONITORING SYSTEM

Unit Test Module / Component	Description	Functionality Percentage	PASS	FAIL	N/A	Date of Testing
PTC Heater 110-220v	Checks the heating element if it reaches 60 C within 15 minutes inside the prototype container					
U-Type Tubular Heating Element	Checks the heating element if it reaches 60 C within 15 minutes inside the prototype container					
Thermocouple K-Type Sensor	Checks thermocouple k-type sensor its interaction with the Arduino and compare its readings with the infrared thermometer.					
Gsm Module Sim900a	Checks the GSM Module Sim900a if it is interacts with Arduino Uno that sends SMS message to the coded number					
Thermostat Control Switch	Checks the Thermostat functionality if it can regulate the specific temperature that the researchers desire					
Push Buttons	Checks the interaction between the push buttons and Arduino Uno					
Web Camera	Checks the image processing of the web camera in terms of detecting Rice Weevils					

The table 3.4 shows on how the researcher test every sensor or module and how it will apply in our prototype. If the actual result will be the same as the expected result, the researchers will check the pass box. However, if it will not be same as expected result, the researchers will check the fail box.

B. Integration Test

Integration test verifies the operation of the integrated system behavior. It is conducted after the system modules have passed a unit test.

TABLE 3.5: TABLE FOR INTEGRATION TESTING

Integration Test	Description	Functionality Percentage	PASS	FAIL	N/A	Date of Testing
MW System IT-A	Checks the interaction between the U-Type Tubular Heating Element, Exhaust Fans, Push Buttons, Relay Modules, LCD Screen, and Arduino Uno					
MW System IT-B	Checks the interaction between Thermostat Control Switch, Thermocouple K-type Sensor, Web Camera, GSM module sim900a, Arduino Uno, and Node MCU					

In Table 3.5 shows the function of the prototype and what the expected results are. Same as the Unit Test, the researchers will check pass fail or N/A in the table. In action will be the response of the system to what the result could be.

C. Acceptance Test

Acceptance test verifies the functionality of the system as a whole. It is conducted after a unit test, and integration test passed its calibration testing.

TABLE 3.6: TABLE FOR ACCEPTANCE TESTING

Test Case Name:	MW Acceptance Test				
Description:	Checks the interaction between U-Type Tubular heating elements, Exhaust fans, push buttons, relay modules, LCD screen, Thermostat control switch, Thermocouple K-Type sensor, Web camera, GSM module sim900a, Node MCU, and Arduino Uno				
Trial Number:	Pass	Fail	N/A	Date of Testing	Comments
1					

In Table 3.6 shows the function of the prototype and what the expected results are. Same as the Unit Test and Integration Test, the researchers will check pass fail or N/A in the table. In action will be the response of the system to what the result could be.

AMA COMPUTER COLLEGE CALAMBA & TACLOBAN
City of Calamba, Laguna

MONITORING AND CONTROLLING THE INFESTATION OF S. ORYZAE AT JAM'S STORE

EVALUATION SHEET

Name :	**Date:**
Age:	**Sex:**
Type of respondents:	
Owner of feed store:	**Owner of rice store:**
Farmer:	**Student:**

INSTRUCTION: Rate the system based on the given criteria by checking the corresponding box.

Evaluation criteria	Outstanding	Above Satisfactory	Satisfactory	Below Satisfactory	Needs Improvements
FUNCTIONALITY					
The proposed system works properly and all expected outcomes are delivered.					
The system is user-friendly and has met the work requirements of the users.					
RELIABILITY					
The proposed system can be used in anytime and place with minimal or without consequences in its functionality.					
The system performs with minimal or without errors during its operation.					
DURABILITY					
The proposed system requires only minimal maintenance after its operation.					

The integrated devices are carefully placed and its rugged in construction.					
EXTENSIBILITY					
The system supports adaptability, and can cope with the varying needs the end-users.					
The system can still be integrated with other electronic devices in the future.					
ECONOMIC FEASIBILITY					
The proposed system offers long term usage and can be considered as a good investment.					
The total cost of the system is practically worth of its performance.					
ANY SUGGESTIONS/RECOMMENDATION:					

Fig. 3.10: Evaluation Sheet for the Proposed System

Figure 3.10 shows the evaluation form. This phase includes the evaluation proper for the system. There is a table of ratings respondents can see as reference on answering the different objectives of the system. These functionality, reliability, durability, extensibility, and economic feasibility.

3.15 ANALYSIS OF DATA GATHERING METHODOLOGY

After the evaluation of the respondents in the evaluation process, the researchers tallied the data that they gathered using the Likert Scale as seen in Table 5. A Likert item is simply a statement that the respondent is asked to evaluate according to any kind of subjective or objective criteria., generally, the level of agreement or disagreement is measured. This can help the researchers to determine the capability of their system. The data has to be thoroughly checked to fulfill the strict formal axioms of the project.

Table 3.7: The Likert Scale

Rating	Scale	Range
5	Outstanding	4.51 - 5.0
4	Above Satisfactory	3.51 - 4.5

3	Satisfactory	2.51 - 3.5
2	Below Satisfactory	1.51 - 2.5
1	Needs Improvement	1.0 - 1.50

The formula is shown below:

$$wm = \frac{O(5) + As(4) + S(3) + Bs(2) + Ni(1)}{N}$$
$$(Eq. 2)$$

WM = Weighted mean
N = Total Number of respondents
5 = Outstanding
4 = Above satisfactory
3 = Satisfactory
2 = Below satisfactory
1 = Needs improvement
The formula to get the Grand Mean is shown below:

$$GM = \frac{Weighted\ mean}{total\ number\ of\ questions}$$

CHAPTER IV
RESULTS AND DISCUSSIONS

This chapter provides the detailed discussion of the developed system/project and shows the results of the evaluation sheet for the proposed system. This also provides the detailed technical discussion of the developed project giving emphasis on both hardware, software, and integration of both.

4.1 THE DEVELOPED SYSTEM

DEVICE	FUNCTIONALITY
MONITORING THE INFESTATION OF SITOPHILUS ORYZAE AT JAM'S STORE	Heating element SMS notification/alert to the Owner of the S. oryzae detection Real-time viewing detection and set timer for the device to serve as START/STOP of controlling the heat temperature of the proposed project.

4.1.1 Program Used

The researchers used Arduino IDE for the utilization of the system and SQL, C++, and JavaScript for the web application. Also, the researchers used Ozeki SMS client for better GSM notifications.

4.2 VERIFICATION AND UNIT TESTING RESULTS

4.2.1 Unit Testing

Unit test is made to check each component if it is working its full function according
Full specification. Each sensor was tested in isolation. It was tested in 30 trials each to meet its calibrating

standards. The researchers agreed to have a passing rate of 85% and above, otherwise if it is below on the passing rate, it will mark as FAILED. This means that the test should only have 4 or less failed tests each 30 trials to meet its passing rate.

TABLE 4.1: Result for Unit Test of PTC Heaters Trial 1

Test Case Name:	PTC Heater 110-220v Unit Test						Date:	09/10.2023
							Time:	10:30am
Description:	Checks the heating element if it reaches 60 C within 15 minutes inside the prototype container						Trial No.	1
Action:	1.) Connect the PTC heaters to relay and Arduino UNO and add a program to switch on heaters for 15 minutes			2.) Connect the PTC heaters to an electric plug and connect it to AC outlet for 15 minutes				
Expected Result:	PTC Heaters should reach its heat index at 60 C within 15 minutes			PTC Heaters should reach its heat index at 60 C within 15 minutes				
Test ID Number:	Pass	Fail	N/A	Pass	Fail	N/A	Remarks	
1		✕			✕		FAILED	
2		✕			✕		FAILED	
3		✕			✕		FAILED	
4		✕			✕		FAILED	
5		✕			✕		FAILED	
6		✕			✕		FAILED	
7		✕			✕		FAILED	
8		✕			✕		FAILED	
9		✕			✕		FAILED	
10		✕			✕		FAILED	
11		✕			✕		FAILED	
12		✕			✕		FAILED	
13		✕			✕		FAILED	
14		✕			✕		FAILED	
15		✕			✕		FAILED	
16		✕			✕		FAILED	
17		✕			✕		FAILED	
18		✕			✕		FAILED	
19		✕			✕		FAILED	
20		✕			✕		FAILED	
21		✕			✕		FAILED	
22		✕			✕		FAILED	
23		✕			✕		FAILED	
24		✕			✕		FAILED	
25		✕			✕		FAILED	
26		✕			✕		FAILED	
27		✕			✕		FAILED	
28		✕			✕		FAILED	
29		✕			✕		FAILED	
30		✕			✕		FAILED	
Note:	FAILED							

Table 4.1 shows the result for unit test of PTC Heaters 110-220v. The unit test checks the heating element to provide a specific heat index that be used in the prototype. It is conducted at 10:30 AM, September 10, 2023. The overall result was FAILED, and it does not meet the researchers' desired outcome.

TABLE 4.2: Summary Result for Unit Test of PTC Heaters Trial 1

Description:	Checks the heating element if it reaches 60 C within 15 minutes inside the prototype container				
Test ID Number:	Pass	Fail	N/A	Date of Testing	Comments
1		✕		September 10. 2023	
2		✕			
3		✕			
4		✕			
5		✕			
6		✕			
7		✕			
8		✕			
9		✕			
10		✕			
11		✕			
12		✕			
13		✕			
14		✕			
15		✕			
16		✕			
17		✕			
18		✕			
19		✕			
20		✕			
21		✕			
22		✕			
23		✕			
24		✕			
25		✕			
26		✕			
27		✕			
28		✕			
29		✕			
30		✕			

Table 4.2 shows the summary result for unit test of PTC heaters. The researchers made the calibration testing 30 times. This unit test checks the sustainability of a heating element to provide a specific 60°C in 15 minutes. Overall, the component has failed the calibration test and resulted to 0% functionality. Researchers decide to look and find for another type of heating element that will sustain and provide the specific heat index of heating element researchers' desire.

TABLE 4.3: Result for Unit Test of U-Type Tubular Heating Element

Test Case Name:	U-Type Tubular Heating Element Unit Test						Date:	09/29/2023
							Time:	1:00pm
Description:	Checks the heating element if it reaches 60°C within 15 minutes inside the prototype container						Trial No:	1
Action:	1.) Connect the tubular heating element to a relay and arduino uno and add a program to switch on heaters for 15			2.) Connect the tubular heating element to an electrical plug and connect to an AC outlet for 15 minutes				
Expected Result:	PTC Heaters should reach its heat index at 60°C within 15 minutes			PTC Heaters should reach its heat index at 60°C within 15 minutes				
Test ID No.	Pass	Fail	N/A	Pass	Fail	N/A	Remarks	
1	✓			✓			PASSED	
2	✓			✓			PASSED	
3	✓			✓			PASSED	
4	✓			✓			PASSED	
5	✓			✓			PASSED	
6	✓			✓			PASSED	
7	✓			✓			PASSED	
8	✓			✓			PASSED	
9		✗		✓			FAILED	
10	✓			✓			PASSED	
11	✓			✓			PASSED	
12	✓			✓			PASSED	
13	✓			✓			PASSED	
14	✓			✓			PASSED	
15	✓				✗		FAILED	
16	✓			✓			PASSED	
17	✓			✓			PASSED	
18	✓			✓			PASSED	
19	✓			✓			PASSED	
20	✓			✓			PASSED	
21	✓			✓			PASSED	
22	✓			✓			PASSED	
23	✓			✓			PASSED	
24	✓			✓			PASSED	
25	✓			✓			PASSED	
26	✓			✓			PASSED	
27	✓			✓			PASSED	
28	✓			✓			PASSED	
29	✓			✓			PASSED	
30	✓			✓			PASSED	
Note:	*Overall, the outcome gives an excellent result. The researchers consider whether AC or DC, the heater will provide the specific amount of heat .*							

Table 4.3 shows the result for unit test of U-Type Tubular Heating Element. This are the heating element researchers' substitute to the PTC Heaters. The unit test checks the heating element to provide a specific heat index that be used in the prototype. It is conducted at 1:00 PM, September 29, 2023. The overall result was PASSED, and it meet the researchers' desired outcome.

TABLE 4.4: Summary Result for Unit Test of U-Type Tubular Heating Element

Description:	Checks the heating element if it reaches 60°C within 15 minutes inside the prototype container				
Test ID	Pass	Fail	N/A	Date of Testing	Comments
1	✔			September 29, 2023	PASSED
2	✔				PASSED
3	✔				PASSED
4	✔				PASSED
5	✔				PASSED
6	✔				PASSED
7	✔				PASSED
8	✔				PASSED
9		✘			Did not reach 60°C in 15 minutes
10	✔				PASSED
11	✔				PASSED
12	✔				PASSED
13	✔				PASSED
14	✔				PASSED
15		✘			Did not reach 60°C in 15 minutes
16	✔				PASSED
17	✔				PASSED
18	✔				PASSED
19	✔				PASSED
20	✔				PASSED
21	✔				PASSED
22	✔				PASSED
23	✔				PASSED
24	✔				PASSED
25	✔				PASSED
26	✔				PASSED
27	✔				PASSED
28	✔				PASSED
29	✔				PASSED
30	✔				PASSED
Overall Test Result:	PASSED				

Table 4.4 shows the summary result for unit test of U-Type tubular heating element. The calibration testing was made 30 times by the researchers. This unit test checks the sustainability of a heating element to provide a specific 60°C in 15 minutes. Overall, the component has PASSED the calibration test and resulted to 93.33% functionality Overall, the component has passed the calibration testing and will be used in the system.

TABLE 4.5: Result for Unit Test of Thermocouple K-Type Sensor

Test Case Name:	Thermocouple K-type Sensor Unit Test						Date:	09-22-2023
							Time:	10:00 am
Description:	Checks thermocouple k-type sensor its interaction with the arduino and compare its readings with the infrared thermometer.						Trial No:	1
Action:	1.) Connect the thermocouple k-type to the max6675 module and test 2 objects with hot and cold water.			2.) Monitor the heat temperature of the PTC Heaters.				
Expected Result:	The result should be same with the result of the infrared thermometer readings.			The result should be same with the result of the infrared thermometer readings.				
Test ID Number:	Pass	Fail	N/A	Pass	Fail	N/A	Remarks:	
1	✓			✓			PASSED	
2	✓			✓			PASSED	
3	✓			✓			PASSED	
4	✓			✓			PASSED	
5	✓			✓			PASSED	
6	✓			✓			PASSED	
7	✓			✓			PASSED	
8	✓			✓			PASSED	
9	✓			✓			PASSED	
10	✓			✓			PASSED	
11	✓			✓			PASSED	
12	✓			✓			PASSED	
13	✓			✓			PASSED	
14	✓			✓			PASSED	
15	✓			✓			PASSED	
16	✓			✓			PASSED	
17	✓			✓			PASSED	
18	✓			✓			PASSED	
19	✓			✓			PASSED	
20	✓			✓			PASSED	
21	✓			✓			PASSED	
22	✓			✓			PASSED	
23	✓			✓			PASSED	
24	✓			✓			PASSED	
25	✓			✓			PASSED	
26	✓			✓			PASSED	
27	✓			✓			PASSED	
28	✓			✓			PASSED	
29	✓			✓			PASSED	
30	✓			✓			PASSED	
Note:	*Overall, the result of this unit test gives an excellent outcome. The researchers consider a +/- 5 in the readings of thermocouple and infrared thermometer.*							

Table 4.5 shows the unit test result of Thermocouple K-Type Sensor. This unit test checks if the thermocouple k-type sensor is accurate for reading high temperature. The researchers used infrared thermometer to determine the accuracy and functionality of the module. It is conducted at 10:00 AM, September 22, 2023. The overall result was PASSED.

TABLE 4.6: Summary Result for Unit Test of Thermocouple K-Type Sensor

Description:	Checks Thermocouple K-Type sensor its interaction with the Arduino Uno and compare its readings with the infrared thermometer				
Test ID:	Pass	Fail	N/A	Date of Testing	Comments
1	✔			September 22, 2023	PASSED
2	✔				PASSED
3	✔				PASSED
4	✔				PASSED
5	✔				PASSED
6	✔				PASSED
7	✔				PASSED
8	✔				PASSED
9	✔				PASSED
10	✔				PASSED
11	✔				PASSED
12	✔				PASSED
13	✔				PASSED
14	✔				PASSED
15	✔				PASSED
16	✔				PASSED
17	✔				PASSED
18	✔				PASSED
19	✔				PASSED
20	✔				PASSED
21	✔				PASSED
22	✔				PASSED
23	✔				PASSED
24	✔				PASSED
25	✔				PASSED
26	✔				PASSED
27	✔				PASSED
28	✔				PASSED
29	✔				PASSED
30	✔				PASSED
Overall Test Result:	PASSED				

Table 4.6 shows the summary result for unit test of Thermocouple K-Type Sensor. The researchers made the calibration testing 30 times. This unit test checks its interaction with the Arduino Uno and compare its reading with the infrared thermometer. Overall, the module has PASSED the calibration test and resulted to 100% functionality.

Overall, the module has passed the calibration testing and will be used in the system.

TABLE 4.7: Result for Unit Test of GSM Module Sim900a

Test Case Name:	Gsm Module Sim900a Unit Test						Date:	09-27-2023
							Time:	1:30 pm
Description:	Checks the Gsm Module Sim900a if it is interacts with Arduino Uno that sends SMS message to the coded number						Trial No.	1
Action:	1.) Insert a simcard to the module sim slot and power the module using arduino through its ground and 5v pins			2.) Add a specific code to the module using Arduino IDE				
Expected Result:	1.) The status/network LED will blink continously every 3 seconds if the network established successfully			2.) The receiver will receive an SMS message from the simcard used in the module				
Test ID Number:	Pass	Fail	N/A	Pass	Fail	N/A	Remarks:	
1		✗			✗		FAILED	
2		✗			✗		FAILED	
3		✗			✗		FAILED	
4	✓				✓		PASSED	
5	✓				✓		PASSED	
6	✓				✓		PASSED	
7	✓				✓		PASSED	
8	✓				✓		PASSED	
9	✓				✓		PASSED	
10	✓				✓		PASSED	
11	✓				✓		PASSED	
12	✓				✓		PASSED	
13	✓				✓		PASSED	
14	✓				✓		PASSED	
15	✓				✓		PASSED	
16	✓				✓		PASSED	
17	✓				✓		PASSED	
18	✓				✓		PASSED	
19	✓				✓		PASSED	
20	✓				✓		PASSED	
21	✓				✓		PASSED	
22	✓				✓		PASSED	
23	✓				✓		PASSED	
24	✓				✓		PASSED	
25	✓				✓		PASSED	
26	✓				✓		PASSED	
27	✓				✓		PASSED	
28	✓				✓		PASSED	
29	✓				✓		PASSED	
30	✓				✓		PASSED	
Note:	*Overall, the result of this unit test gives an excellent outcome. The researchers consider a network provider that will suit the test.*							

Table 4.7 shows the result of unit test of GSM Module Sim900a. This unit test checks if the module interacts with the Arduino Uno and sends SMS message to the coded recipient. It is conducted at 1:30 PM, September 27, 2023. The overall result was PASSED.

TABLE 4.8: Summary Result for Unit Test of GSM Module Sim900a

Description:	Checks the Gsm Module Sim900a if it is interacts with Arduino Uno that sends SMS message to the coded number				
Test ID No.	Pass	Fail	N/A	Date of Testing	Comments
1		✗		September 27, 2023	FAILED
2		✗			FAILED
3		✗			FAILED
4	✓				PASSED
5	✓				PASSED
6	✓				PASSED
7	✓				PASSED
8	✓				PASSED
9	✓				PASSED
10	✓				PASSED
11	✓				PASSED
12	✓				PASSED
13	✓				PASSED
14	✓				PASSED
15	✓				PASSED
16	✓				PASSED
17	✓				PASSED
18	✓				PASSED
19	✓				PASSED
20	✓				PASSED
21	✓				PASSED
22	✓				PASSED
23	✓				PASSED
24	✓				PASSED
25	✓				PASSED
26	✓				PASSED
27	✓				PASSED
28	✓				PASSED
29	✓				PASSED
30	✓				PASSED
Overall Test Result:	PASSED				

Table 4.8 shows the summary result for unit test of GSM Module Sim900a. The calibration testing was made 30 times by the researchers. This unit test checks the module to its interaction with the Arduino Uno and apply a specific code through the Arduino IDE. Overall, the module PASSED the calibration test and resulted to 90% functionality.

Overall, the module has passed the calibration test and will be used in the system.

TABLE 4.9: Result for Unit Test of Thermostat Control Switch

Test Case Name:	Thermostat Control Switch Unit Test						Date:	10/05/2023
							Time:	9:00 am
Description:	Checks the Thermostat functionality if it can regulate the specific temperature that the researchers desire						Trial No.	1
Action:	1.) Make a circuit with the thermostat control switch using Arduino Uno, heating element and a relay within a container box			2.) Set a specific temperature on the thermostat which command to switch on the relay				
Expected Result:	1.) The thermostat will turn on when plug to an outlet and display temperature on thermostat control switch display			2.) The relay will switch on to activate the heating element when container box is below 40°C and switch off when temperature is above 45°C				
Test ID No.	Pass	Fail	N/A	Pass	Fail	N/A	Remarks	
1	✓			✓			PASSED	
2	✓			✓			PASSED	
3	✓				✗		FAILED	
4	✓			✓			PASSED	
5	✓			✓			PASSED	
6	✓			✓			PASSED	
7		✗		✓			FAILED	
8	✓			✓			PASSED	
9	✓			✓			PASSED	
10	✓			✓			PASSED	
11	✓			✓			PASSED	
12	✓			✓			PASSED	
13	✓			✓			PASSED	
14	✓			✓			PASSED	
15	✓			✓			PASSED	
16	✓			✓			PASSED	
17	✓			✓			PASSED	
18	✓			✓			PASSED	
19	✓			✓			PASSED	
20	✓			✓			PASSED	
21	✓			✓			PASSED	
22	✓			✓			PASSED	
23	✓			✓			PASSED	
24	✓			✓			PASSED	
25	✓			✓			PASSED	
26	✓			✓			PASSED	
27	✓			✓			PASSED	
28	✓			✓			PASSED	
29	✓			✓			PASSED	
30	✓			✓			PASSED	
Note:	*Overall, the outcome gives an excellent result. The researchers tested the thermostat control switch through direct an AC plug and through ac relay module with Arduino Uno*							

Table 4.9 shows the result of the unit test of thermostat control switch. This unit test checks if the component can regulate the specific temperature researchers desired. It is conducted at 9:00 AM, October 5, 2023. The overall result was PASSED.

TABLE 4.10: Summary Result for Unit Test of Thermostat Control Switch

Description:	Checks the Thermostat functionality if it can regulate the specific temperature that the researchers desire				
Test ID No.	Pass	Fail	N/A	Date of Testing	Comments
1	✔			October 5, 2023	PASSED
2	✔				PASSED
3		✘			FAILED
4	✔				PASSED
5	✔				PASSED
6	✔				PASSED
7		✘			FAILED
8	✔				PASSED
9	✔				PASSED
10	✔				PASSED
11	✔				PASSED
12	✔				PASSED
13	✔				PASSED
14	✔				PASSED
15	✔				PASSED
16	✔				PASSED
17	✔				PASSED
18	✔				PASSED
19	✔				PASSED
20	✔				PASSED
21	✔				PASSED
22	✔				PASSED
23	✔				PASSED
24	✔				PASSED
25	✔				PASSED
26	✔				PASSED
27	✔				PASSED
28	✔				PASSED
29	✔				PASSED
30	✔				PASSED
Overall Test Result:	PASSED				

Table 4.10 shows the summary result for unit test of Thermostat Control Switch. The calibration testing was made 30 times by the researchers. This unit checks the module functionality to regulate the specific temperature researchers desired. Overall, the module PASSED the calibration test and resulted to 93.33% functionality.

Overall, the module has passed the calibration test and will used in the system.

TABLE 4.11: Result for Unit Test of Push Buttons

Test Case Name:	Push Buttons Unit Test						Date:	10/08/2023
							Time:	11:00 am
Description:	Checks the interaction between the push buttons and Arduino Uno						Trial No.	1
Action:	Add a program where the first button should start process after pressed			Add a program where the first button should stop process after pressed				
Expected Result:	Relay module connected to the Arduino and connected to the heating element will switched on when pressed			Relay module connected to the Arduino and connected to the heating element will switched off when pressed				
Test ID Number:	Pass	Fail	N/A	Pass	Fail	N/A	Remarks:	
1	✓			✓			PASSED	
2		✗		✓			FAILED	
3		✗		✓			FAILED	
4	✓			✓			PASSED	
5	✓			✓			PASSED	
6	✓			✓			PASSED	
7	✓			✗			FAILED	
8	✓			✓			PASSED	
9	✓			✓			PASSED	
10	✓			✓			PASSED	
11	✓			✓			PASSED	
12	✓			✓			PASSED	
13	✓			✓			PASSED	
14	✓			✓			PASSED	
15	✓			✗			FAILED	
16	✓			✓			PASSED	
17	✓			✓			PASSED	
18	✓			✓			PASSED	
19	✓			✓			PASSED	
20	✓			✓			PASSED	
21	✓			✓			PASSED	
22	✓			✓			PASSED	
23	✓			✓			PASSED	
24	✓			✓			PASSED	
25	✓			✓			PASSED	
26	✓			✓			PASSED	
27	✓			✓			PASSED	
28	✓			✓			PASSED	
29	✓			✓			PASSED	
30	✓			✓			PASSED	
Note:	*Overall, the result gives an excellent outcome. The researchers got the desired outcome and will use push buttons in the system*							

Table 4.10 shows the result of the unit test of Push Buttons. This unit test checks if it interacts with the Arduino Uno when given a specific process when pressed. It is conducted at 11:00 am. October 8, 2023. The overall result was PASSED.

TABLE 4.12: Summary Result for Unit Test of Push Buttons

Description:	Checks the interaction between the push buttons and Arduino Uno				
Test ID No.	Pass	Fail	N/A	Date of Testing	Comments
1	✔			October 8, 2023	PASSED
2		✘			FAILED
3		✘			FAILED
4	✔				PASSED
5	✔				PASSED
6	✔				PASSED
7		✘			FAILED
8	✔				PASSED
9	✔				PASSED
10	✔				PASSED
11	✔				PASSED
12	✔				PASSED
13	✔				PASSED
14	✔				PASSED
15		✘			FAILED
16	✔				PASSED
17	✔				PASSED
18	✔				PASSED
19	✔				PASSED
20	✔				PASSED
21	✔				PASSED
22	✔				PASSED
23	✔				PASSED
24	✔				PASSED
25	✔				PASSED
26	✔				PASSED
27	✔				PASSED
28	✔				PASSED
29	✔				PASSED
30	✔				PASSED
Overall Test Result:	PASSED				

Table 4.12 shows the summary result for unit test of Push Buttons. The calibration testing was made 30 times by the researchers. This unit test checks the component's functionality and a good interaction within the Arduino Uno. Overall, the component PASSED the calibration test and resulted to 86.66% functionality.

Overall, the module has passed the calibration test and will used in the system.

TABLE 4.13: Result for Unit Test of Web Camera Trial 1

Test Case Name:	Web Camera Unit Test						Date:	10/13/2023
							Time:	3:30 pm
Description:	Checks the image processing of the web camera in terms of detecting Rice Weevils						Trial No.	1
Action:	Create a web page where you can view what camera captures			Add an image processing function that detects a black or brown Rice Weevil				
Expected Result:	Access on web page where you can view a real-time video			Recognition of a black or brown parasite and follows their movement				
Test ID Number:	Pass	Fail	N/A	Pass	Fail	N/A	Remarks:	
1	✔			✔			PASSED	
2	✔				✘		FAILED	
3	✔				✘		FAILED	
4	✔				✘		FAILED	
5	✔				✘		FAILED	
6	✔				✘		FAILED	
7	✔				✘		FAILED	
8	✔			✔			PASSED	
9	✔				✘		FAILED	
10	✔				✘		FAILED	
11	✔				✘		FAILED	
12	✔				✘		FAILED	
13	✔				✘		FAILED	
14	✔				✘		FAILED	
15	✔				✘		FAILED	
16	✔			✔			PASSED	
17	✔			✔			PASSED	
18	✔				✘		FAILED	
19	✔				✘		FAILED	
20	✔				✘		FAILED	
21	✔				✘		FAILED	
22	✔			✔			PASSED	
23	✔			✔			PASSED	
24	✔			✔			PASSED	
25	✔			✔			PASSED	
26	✔				✘		FAILED	
27	✔				✘		FAILED	
28	✔				✘		FAILED	
29	✔				✘		FAILED	
30	✔			✔			PASSED	
Note:	*Overall, the result gives a poor outcome. The researchers will adjust their code and seek advice from the programmer. Therefore, the researchers will proceed to second trial.*							

Table 4.13 shows the result of the unit test of Web Camera. This unit test checks the image processing of a web camera on detecting the rice weevils. It is conducted at 3:30 PM, October 13, 2023. The overall result was FAILED.

TABLE 4.14: Summary Result for Unit Test of Web Camera Trial 1

Description:	Checks the image processing of the web camera in terms of detecting Rice Weevils				
Test ID Number:	Pass	Fail	N/A	Date of Testing	Comments
1	✔			October 13, 2023	PASSED
2		X			FAILED
3		X			FAILED
4		X			FAILED
5		X			FAILED
6		X			FAILED
7		X			FAILED
8	✔				PASSED
9		X			FAILED
10		X			FAILED
11		X			FAILED
12		X			FAILED
13		X			FAILED
14		X			FAILED
15		X			FAILED
16	✔				PASSED
17	✔				PASSED
18		X			FAILED
19		X			FAILED
20		X			FAILED
21		X			FAILED
22	✔				PASSED
23	✔				PASSED
24	✔				PASSED
25	✔				PASSED
26		X			FAILED
27		X			FAILED
28		X			FAILED
29		X			FAILED
30	✔				PASSED
Overall Test Result:	FAILED				

Table 4.14 shows the summary result for unit test of Web Camera. The calibration testing was made 30 times by the researchers. This unit test checks the image processing of web camera in terms of detecting Rice Weevils. Overall, the component FAILED the calibration test and resulted to 30% functionality. The researchers will proceed to the second trial of this unit test.

TABLE 4.15: Result for Unit Test of Web Camera Trial 2

Test Case Name:	Web Camera Unit Test						Date:	10/15/2023
							Time:	10:00am
Description:	Checks the image processing of the web camera in terms of detecting Rice Weevils						Trial No.	2
Action:	Create a web page where you can view what camera captures			Add an image processing function that detects a black or brown Rice Weevil				
Expected Result:	Access on web page where you can view a real-time video			Recognition of a black or brown parasite and follows their movement				
Test ID Number:	Pass	Fail	N/A	Pass	Fail	N/A	Remarks:	
1	✔			✔			PASSED	
2	✔			✔			PASSED	
3	✔				✘		FAILED	
4	✔			✔			PASSED	
5	✔			✔			PASSED	
6	✔			✔			PASSED	
7	✔			✔			PASSED	
8	✔			✔			PASSED	
9	✔			✔			PASSED	
10	✔			✔			PASSED	
11	✔			✔			PASSED	
12	✔			✔			PASSED	
13	✔			✔			PASSED	
14	✔			✔			PASSED	
15	✔			✔			PASSED	
16	✔			✔			PASSED	
17	✔			✔			PASSED	
18	✔			✔			PASSED	
19	✔			✔			PASSED	
20	✔			✔			PASSED	
21	✔			✔			PASSED	
22	✔			✔			PASSED	
23	✔			✔			PASSED	
24	✔			✔			PASSED	
25	✔			✔			PASSED	
26	✔			✔			PASSED	
27	✔			✔			PASSED	
28	✔				✘		FAILED	
29	✔			✔			PASSED	
30	✔			✔			PASSED	
Note:	*Overall, the result gives an excellent outcome. Upon the second trial,the researchers achieve their desire outcome.*							

Table 4.15 shows the result of the unit test of Web Camera Trial 2. This unit test checks the image processing of a web camera on detecting the rice weevils. It is conducted at 10:00 am, October 15, 2023. The overall result was PASSED.

TABLE 4.16: Summary Result for Unit Test of Web Camera Trial 2

Description	Checks the image processing of the web camera in terms of detecting Rice Weevils				
Test ID Number:	Pass	Fail	N/A	Date of Testing	Comments
1	✔			October 15, 2023	PASSED
2	✔				PASSED
3		✘			FAILED
4	✔				PASSED
5	✔				PASSED
6	✔				PASSED
7	✔				PASSED
8	✔				PASSED
9	✔				PASSED
10	✔				PASSED
11	✔				PASSED
12	✔				PASSED
13	✔				PASSED
14	✔				PASSED
15	✔				PASSED
16	✔				PASSED
17	✔				PASSED
18	✔				PASSED
19	✔				PASSED
20	✔				PASSED
21	✔				PASSED
22	✔				PASSED
23	✔				PASSED
24	✔				PASSED
25	✔				PASSED
26	✔				PASSED
27	✔				PASSED
28		✘			FAILED
29	✔				PASSED
30	✔				PASSED
Overall Test Result:	PASSED				

Table 4.16 shows the summary result for unit test of Web Camera Trial 2. The calibration testing was made 30 times by the researchers. This unit test checks the image processing of web camera in terms of detecting Rice Weevils. Overall, the component PASSED the calibration test and resulted to 93.33% functionality.

Overall, the module has passed the calibration test and will used in the system.

TABLE 4.17: Table for Result of Unit Testing

Unit Test Module / Component	Description	Functionality Percentage	PASS	FAIL	N/A	Date of Testing
PTC Heater 110-220v	Checks the heating element if it reaches 60 C within 15 minutes inside the prototype container	0%		✗		September 10, 2023
U-Type Tubular Heating Element	Checks the heating element if it reaches 60 C within 15 minutes inside the prototype container	93.33%	✔			September 29, 2023
Thermocouple K-Type Sensor	Checks thermocouple k-type sensor its interaction with the Arduino and compare its readings with the infrared thermometer.	100.00%	✔			September 22, 2023
Gsm Module Sim900a	Checks the GSM Module Sim900a if it is interacts with Arduino Uno that sends SMS message to the coded number	90.00%	✔			September 27, 2023
Thermostat Control Switch	Checks the Thermostat functionality if it can regulate the specific temperature that the researchers desire	93.33%	✔			October 5, 2023
Push Buttons	Checks the interaction between the push buttons and Arduino Uno	86.66%	✔			October 8, 2023
Web Camera (Trial 1)	Checks the image processing of the web camera in terms of detecting Rice Weevils	30.00%		✗		October 13, 2023
Web Camera (Trial 2)	Checks the image processing of the web camera in terms of detecting Rice Weevils	93.33%	✔			October 15, 2023

Table 4.17 shows the summary result of unit tests of individual modules or components. PTC Heater 110-220v failed the testing with 0% functionality and the researchers find another heating element to be used in the system, Thus, PTC heater is a component excluded by the researchers. U-type tubular heating element passed the testing with 93.33% functionality. Thermocouple K-type sensor with 100% functionality. GSM module sim900a with 90% functionality. Thermostat control switch with 93.33% functionality. Push buttons gives 86.66% functionality. Web camera trial 1 failed the testing with only 30% functionality rate. The researchers proceed to trial 2 of the Web camera unit test and results to 93.33% functionality.

4.2.2 Integration Testing

Integration test verifies the specific interaction between the modules / components that
will be used in the system. Integration testing conducted after all the modules / components have passed the unit testing. Integration test consist of MW System IT-A which consists the interaction of U-type tubular heating element, push buttons, exhaust fan, 4 pin rocker switch, Arduino Uno and MW System IT-B that consists of relay modules, buzzer, thermostat control switch, thermocouple k-type sensor, web camera, GSM module sim900a, Arduino Uno, and NodeMCU.

Integration test verifies the operation of the integrated system. The circuit should function as follows: the heating element that connected to the relay module should switch on when the first button is pressed thus,

it will switch off when the third button is pressed. Also, a text message will be sent to the programmed recipient when the heating element is switched on or off.

The calibration test in each integrated circuits will be done 20 times each trials. The researchers should get a 100% functionality in order to have their testing mark as PASSED.

Table 4.18: Result for Integration Test for MW System IT-A Trial 1

Test Case Name:	MW System Integration Test A						Date:	10/20/2023
							Time:	8:30am
Description:	Checks the interaction between the U-Type Tubular Heating Element, Exhaust Fans, Push Buttons, Relay Modules, LCD Screen, and Arduino Uno						Trial No.	1
Action:	Lay down a code to Arduino IDE where the U-Type Tubular Heating and Exhaust fan that connected to the relay modules should switch on when specific push button is pressed				Adding a code where the whole integration system stops when red button is pressed			
Expected Result:	A dashboard display "Select Mode" when no buttons are pressed	Relay Modules will switch on if first or second button is pressed	Integration System A would process for 5 minutes if first button is pressed	Integration System A would process for 15 minutes if second button is pressed	Relay Modules will switch off if first or second button is pressed	A dashboard display "Select Mode" when no buttons are pressed		
Test ID Number:							Remarks:	
1	✓	✓	✓	✓	✓	✓	PASSED	
2	✓	✓	✓	✓	✓	✓	PASSED	
3	✓	✓	✓	✓	✓	✓	PASSED	
4	✓	✓	✓	✓	✓	✓	PASSED	
5	✓	✓	✓	✗	✗	✓	FAILED	
6	✗	✓	✗	✓	✗	✗	FAILED	
7	✓	✓	✓	✓	✓	✓	PASSED	
8	✓	✓	✓	✓	✓	✓	PASSED	
9	✓	✓	✓	✓	✓	✓	PASSED	
10	✓	✓	✓	✗	✗	✓	FAILED	
11	✓	✓	✓	✓	✓	✓	PASSED	
12	✓	✓	✗	✓	✗	✓	FAILED	
13	✓	✓	✓	✗	✗	✓	FAILED	
14	✓	✓	✓	✓	✓	✓	PASSED	
15	✓	✓	✓	✓	✓	✓	PASSED	
16	✓	✗	✓	✓	✓	✓	FAILED	
17	✓	✓	✓	✓	✓	✓	PASSED	
18	✓	✓	✓	✓	✓	✓	PASSED	
19	✓	✓	✓	✓	✓	✓	PASSED	
20	✗	✗	✗	✓	✗	✗	FAILED	
Overall Test Result:	FAILED							

Table 4.18 shows the outcome of integration testing of MW System IT-A Trial 1. The integrated circuit have its function as follows: A dashboard displays on the LCD screen when no buttons are pressed “Select Mode, Quick Heating or Deep Heating”. The integrated system a will process for 5 minutes heating when first button is pressed. The integrated system a will process for 15-20 minutes heating when second button is pressed. The process neither quick heating or deep heating will stop its process when third button is pressed.

This result mark as FAILED. Test ID numbers, 5, 6, 10, 12, 13, and 20 failed the testing. Expected result did not meet the testing where the relay module did not switch off when the third button is pressed. LCD screen did not display any character when the process resets. And integrated system did not process to the specific 5 minute and 15 minutes' runtime process.

Overall, the integrated circuit failed the calibration testing for integration test. It only gives an 65% functionality. Researchers extend its trial and proceeds to second trial.

Table 4.19: Result for Integration Test for MW System IT-A Trial 2

Test Case Name:	MW System Integration Test A						Date:	10/21/2023
							Time:	9:30 am
Description:	Checks the interaction between the U-Type Tubular Heating Element, Exhaust Fans, Push Buttons, Relay Modules, LCD Screen, and Arduino Uno						Trial No.	2
Action:	Lay down a code to Arduino IDE where the U-Type Tubular Heating and Exhaust fan that connected to the relay modules should switch on when specific push button is pressed				Adding a code where the whole integration system stops when red button is pressed			
Expected Result:	A dashboard display "Select Mode" when no buttons are pressed	Relay Modules will switch on if first or second button is pressed	Integration System A would process for 5 minutes if first button is pressed	Integration System A would process for 15 minutes if second button is pressed	Relay Modules will switch off if first or second button is pressed	A dashboard display "Select Mode" when no buttons are pressed		
Test ID Number:							Remarks:	
1	✔	✔	✔	✔	✔	✔	PASSED	
2	✔	✔	✔	✔	✔	✔	PASSED	
3	✔	✔	✔	✔	✔	✔	PASSED	
4	✔	✔	✔	✔	✔	✔	PASSED	
5	✔	✔	✔	✔	✔	✔	PASSED	
6	✔	✔	✔	✔	✔	✔	PASSED	
7	✔	✔	✔	✔	✔	✔	PASSED	
8	✔	✔	✔	✔	✔	✔	PASSED	
9	✔	✔	✔	✔	✔	✔	PASSED	
10	✔	✔	✔	✔	✔	✔	PASSED	
11	✔	✔	✔	✔	✔	✔	PASSED	
12	✔	✔	✔	✔	✔	✔	PASSED	
13	✔	✔	✔	✔	✔	✔	PASSED	
14	✔	✔	✔	✔	✔	✔	PASSED	
15	✔	✔	✔	✔	✔	✔	PASSED	
16	✔	✔	✔	✔	✔	✔	PASSED	
17	✔	✔	✔	✔	✔	✔	PASSED	
18	✔	✔	✔	✔	✔	✔	PASSED	
19	✔	✔	✔	✔	✔	✔	PASSED	
20	✔	✔	✔	✔	✔	✔	PASSED	
Overall Result:	PASSED							

Table 4.19 shows the outcome of integration testing of MW System IT-A Trial 1. The calibration testing for the integrated system was made 20 times conducted at 8:30 am, October 22, 2023. The integration test checks and verifies the interaction between the U-type tubular heating element, exhaust fans, relay modules, push buttons, LCD screen, and Arduino Uno. The system will start neither first or second button

is pressed. A dashboard will appear on LCD screen with a character of "Select Mode" when the process completes and when no buttons are pressed. The integrated system process will stop when third button is pressed. The process will last to 5 minutes when first button is pressed and 15 minutes when second button is pressed.

Overall, the integrated circuit passed the calibration testing on second trial which gives a 100% functionality.

Table 4.20: Summary Result for Integration Test of MW System IT-A

Test Case Name:	MW System IT-A				
Description:	Checks the interaction between the U-Type Tubular Heating Element, Exhaust Fans, Push Buttons, Relay Modules, LCD Screen, and Arduino Uno				
Trial Number:	Pass	Fail	N/A	Date of Testing	Comments:
1		✕		October 20, 2023	*Relay module to stop process did not switch off when third button is pressed 5 and 15 minutes' process is incomplete and relay module switched off LCD Screen did not display any character*
2	✔			October 22, 2023	

Table 4.20 shows the summary result for the integration test of MW System IT-A. 2 trials was conducted by the researchers and each trials consists of 20 tests for it calibration which result to the main function of the system. Each buttons programmed with specific functions. When first button is pressed, the relay module will switch on and the u-type tubular heating element and exhaust fan will run for 5 minutes. On the other hand, when second button is pressed, a relay module will trigger to switch on and the heating element and exhaust fan will run for 15 minutes. Therefore, when third button is pressed, neither first or second process will stop. A dashboard displays to the LCD screen when no buttons are pressed or when a process stops. Trial 1 marked as fail for giving a 65% functionality percentage. Relay module did not work as what researchers expected. LCD screen did not display any characters for several times. Trial 2 mark as passed for giving a 100% functionality percentage. The trial conducted at 8:30 am, October 22, 2023

Table 4.21: Result for Integration Test for MW System IT-B Trial 1

Test Case Name:	MW System Integration Test IT-B					Date:	10/29/2023
						Time:	1:20 pm
Description:	Checks the interaction between Thermostat Control Switch, Thermocouple K-type Sensor, Web Camera, GSM module sim900a, Arduino Uno, and Node MCU					Trial No.	1
Action:	Press the second button			Press and control buttons through web application			
Expected Result:	"Deep Heating" start its process	Exhaust fans and heating element will switch off when 60°C is reached	SMS message will sent to the coded recipient when the system starts, stops, and completed	SMS Message of "Alert! There is a weevil in the rice" will sent to the recipient when the web camera detects a rice weevil	View a real-time point of view of the web camera where you can see if there is a rice weevil through webpage		
Test ID Number:						Remarks:	
1	✔	✔	✘	✘	✘	FAILED	
2	✔	✔	✘	✘	✘	FAILED	
3	✔	✔	✘	✘	✔	FAILED	
4	✔	✔	✘	✘	✘	FAILED	
5	✔	✔	✔	✘	✔	FAILED	
6	✔	✔	✔	✘	✔	FAILED	
7	✔	✔	✔	✘	✔	FAILED	
8	✔	✔	✔	✔	✔	PASSED	
9	✔	✔	✔	✔	✔	PASSED	
10	✔	✔	✔	✔	✔	PASSED	
11	✔	✔	✔	✔	✔	PASSED	
12	✔	✔	✔	✔	✘	FAILED	
13	✔	✔	✔	✔	✘	FAILED	
14	✔	✔	✔	✔	✘	FAILED	
15	✔	✔	✘	✔	✘	FAILED	
16	✔	✔	✘	✔	✘	FAILED	
17	✔	✔	✘	✔	✔	FAILED	
18	✔	✔	✔	✔	✔	PASSED	
19	✔	✔	✔	✘	✔	FAILED	
20	✔	✔	✘	✘	✔	FAILED	
Overall Result:	FAILED						

Table 4.21 shows the outcome of integration testing of MW System IT-A Trial 2. The integrated circuit have its function as follows: When second button is pressed, “Deep Heating” will start its process. An SMS message will send to the recipient whenever the system starts, stops, or completed the deep heating process. Upon deep heating process, temperature regulates between 50-60°C by automatically switch off the relay that connects the heating element and exhaust fans. Also, you can control the push button function on a website. You can have an access to a website whereas you can view a real-time point of view of the web camera. When a rice weevil is detected, an SMS message will send to the recipient with characters of “Alert! There is a weevil in the rice”.

The result mark as FAILED. Test ID numbers, 1, 2, 3, 4, 5, 6, 7, 12, 13, 14, 15, 16, 17, 19, and 20 failed the testing. SMS message did not receive by the coded recipient when the system starts, stops, or

completed. Also, some tests did not send an SMS message to the recipient when rice weevil is detected. Lastly, this trial had some errors that it did not display the camera on the webpage.

Overall, the integrated circuit failed the calibration testing for integration test. It only gives an 25% functionality percentage. Researchers will to the second trial.

Table 4.22: Result for Integration Test for MW System IT-B Trial 2

Test Case Name:	MW System Integration Test IT-B					Date:	11/04/2023
						Time:	9:20am
Description:	Checks the interaction between Thermostat Control Switch, Thermocouple K-type Sensor, Web Camera, GSM module sim900a, Arduino Uno, and Node MCU					Trial No.	2
Action	Press the second button			Press and control buttons through web application			
Expected Result:	"Deep Heating" start its process	Exhaust fans and heating element will switch off when 60°C is reached	SMS message will sent to the coded recipient when the system starts, stops, and completed	SMS Message of "Alert! There is a weevil in the rice" will sent to the recipient when the web camera detects a rice weevil	View a real-time point of view of the web camera where you can see if there is a rice weevil through webpage		
Test ID Number:						Remarks:	
1	✓	✓	✓	✓	✗	FAILED	
2	✓	✓	✓	✓	✗	FAILED	
3	✓	✓	✓	✓	✗	FAILED	
4	✓	✓	✓	✓	✓	PASSED	
5	✓	✓	✓	✓	✓	PASSED	
6	✓	✓	✓	✓	✓	PASSED	
7	✓	✓	✓	✓	✓	PASSED	
8	✓	✓	✓	✓	✓	PASSED	
9	✓	✓	✓	✓	✓	PASSED	
10	✓	✓	✓	✓	✓	PASSED	
11	✓	✓	✓	✓	✓	PASSED	
12	✓	✓	✓	✓	✓	PASSED	
13	✓	✓	✓	✓	✓	PASSED	
14	✓	✓	✓	✓	✓	PASSED	
15	✓	✓	✓	✗	✓	FAILED	
16	✓	✓	✗	✗	✓	FAILED	
17	✓	✓	✓	✗	✓	FAILED	
18	✓	✓	✓	✓	✓	PASSED	
19	✓	✓	✓	✓	✗	FAILED	
20	✓	✓	✗	✗	✓	FAILED	
Overall Test Result:	FAILED						

The result mark as FAILED as test ID numbers, 1, 2, 3, 15, 16, 17, 19, and 20 failed the testing. SMS message did not receive by the coded recipient when the system starts, stops, or completed. Also, some tests did not send an SMS message to the recipient when rice weevil is detected. Lastly, this trial had some errors that it did not display the camera on the webpage.

Overall, the integrated circuit failed the calibration testing for integration test. It only gives an 60% functionality percentage. Researchers will to the third trial.

Table 4.23: Result for Integration Test for MW System IT-B Trial 3

Test Case Name:	MW System Integration Test IT-B					Date:	11/09/2023
						Time:	8:25am
Description:	Checks the interaction between Thermostat Control Switch, Thermocouple K-type Sensor, Web Camera, GSM module sim900a, Arduino Uno, and Node MCU					Trial No.	3
Action:	Press the second button			Press and control buttons through web application			
Expected Result:	"Deep Heating" start its process	Exhaust fans and heating element will switch off when 60°C is reached	SMS message will sent to the coded recipient when the system starts, stops, and completed	SMS Message of "Alert! There is a weevil in the rice" will sent to the recipient when the web camera detects a rice weevil	View a real-time point of view of the web camera where you can see if there is a rice weevil through webpage		
Test ID Number:						Remarks:	
1	✔	✔	✔	✔	✔	PASSED	
2	✔	✔	✔	✔	✔	PASSED	
3	✔	✔	✔	✔	✔	PASSED	
4	✔	✔	✔	✔	✔	PASSED	
5	✔	✔	✔	✔	✔	PASSED	
6	✔	✔	✔	✔	✔	PASSED	
7	✔	✔	✔	✔	✔	PASSED	
8	✔	✔	✔	✔	✔	PASSED	
9	✔	✔	✔	✔	✔	PASSED	
10	✔	✔	✔	✔	✔	PASSED	
11	✔	✔	✔	✔	✔	PASSED	
12	✔	✔	✔	✔	✔	PASSED	
13	✔	✔	✔	✔	✔	PASSED	
14	✔	✔	✔	✔	✔	PASSED	
15	✔	✔	✔	✔	✔	PASSED	
16	✔	✔	✔	✔	✔	PASSED	
17	✔	✔	✔	✔	✔	PASSED	
18	✔	✔	✔	✔	✔	PASSED	
19	✔	✔	✔	✔	✔	PASSED	
20	✔	✔	✔	✔	✔	PASSED	
Overall Test Result:	PASSED						

Table 4.23 shows the outcome of integration testing of MW System IT-B Trial 3. The calibration testing for the integrated system was made 20 times conducted at 8:25 am, November 9, 2023. The integration test checks and verifies the interaction between the Thermostat Control Switch, Thermocouple K-Type sensor, Web Camera, GSM module sim900a, Arduino Uno, and Node MCU. The integrated system will start when second button is pressed. The “deep heating” process will start and an SMS message will send to the coded recipient as a notification that the starts is deep heating. Also, an SMS message will send whenever the process completed or the user stops its process by pressing the third button. The temperature inside is regulated using a Thermocouple sensor whereas when the temperature inside is reached at 60°C,

the heating element and exhaust fan will switch off. By accessing the specific webpage, you can view a real-time point of view of the camera. An SMS message will send to the recipient whenever a camera detects a rice weevil in the system.

Overall, the integrated circuit passed the calibration testing on third trial which gives a 100% functionality.

Table 4.24: Summary Result for Integration Test of MW System IT-B

Test Case Name:	MW System IT-B				
Description:	Checks the interaction between Thermostat Control Switch, Thermocouple K-type Sensor, Web Camera, GSM module sim900a, Arduino Uno, and Node MCU				
Trial Number:	Pass	Fail	N/A	Date of Testing	Comments:
1		✕		October 29, 2023	*SMS message did not receive when integrated system starts* *No SMS message alert when a rice weevil is detected* *No real-time point of view of the camera on the webpage*
2		✕		November 04, 2023	*No SMS message alert when a rice weevil is detected* *No real-time point of view of the camera on the webpage*
3	✔			November 09, 2023	

Table 4.24 shows the summary result for the integration test of MW System IT-B. 3 trials was conducted by the researchers and each trials consists of 20 tests for it calibration which result to the main function of the system. Second button is pressed that leads to the "Deep Heating" mode process. When a deep heating starts its process, an SMS message will send to the coded recipient. It will act as a notification whenever the system starts, stops, or completed. Push button can also be controlled in a webpage. This is where the interaction of Arduino Uno and Node MCU occurred. A real-time point of view of camera can be viewed through a webpage. By a specific program, web camera can detect if the is a rice weevil on the integrated system. An SMS message with character of "Alert! There is a weevil in the rice" will be send to the coded recipient. Trial 1 marked as fail for giving a 25% functionality percentage. No SMS message received upon starting he integrated system. No SMS message received when there is rice weevil detected and no real-time point of view of the web camera appeared on the webpage. Trial 2 mark as fail for giving a 60% functionality percentage. No SMS message received when a rice weevil is detected and no real-time point of web camera appeared on the webpage. Trial 3 marked as passed for giving a 100% functionality percentage. It passed all the 20 calibration tests in this trial and it is conducted at 8:25 am, November 9, 2023.

4.2.3 Acceptance Testing

Acceptance test verifies the functionality of the system as a whole. It is conducted after a unit test, and integration test passed its calibration testing.

Researchers will not stop attempting their trials until they reach a 100% functionality percentage. Each trial consists of 15 tests which indicate all the functions of the combined integrated system. Each error will be discussed by the researcher for future purposes in case of related studies will be conducted and same error is occurred.

Acceptance testing of MW System should start when the rocker switch is switched on. Rocker switch is the main switch that power on and power off the whole system. Once the system powered on, a dashboard will appear to the LCD screen with characters "Select Mode: Quick Heating or Deep Heating". When first button is pressed quick heating is processed. A relay module connected to the heating element and exhaust fan will switch on for 30 minutes when first button is pressed. Once it process, temperature captured by the Thermocouple K-Type sensor will appear to the LCD Screen. A timer of 30 minutes also appeared in the LCD screen. You can view the real-time point of view of the web camera by accessing the specific webpage. An SMS message will send to the recipient whenever the process starts, stops, or completed. Also, recipient will receive an SMS alert with character "Alert! There is a weevil in the rice" whenever the web camera detects a rice weevil. Same goes when you process the deep heating. Once you pressed the second button, a relay module connected to the heating element and exhaust fan will switch on for 60 minutes. Once the deep heating is nearly completed, the system will let you choose if you need to do extra 5 minutes heating. It will proceed for another 5 minutes if you pressed the first button. If you don't need another 5 minutes, just press second to complete the deep heating process. You can control all the buttons on a specific webpage. Temperature will only regulate to maximum of 60°C and minimum 40°C of heat index using the thermostat control switch.

The calibration test in the whole system will be done 15 times each trials. The researchers should get a 100% functionality in order to have their testing mark as PASSED.

Table 4.25: Result for Acceptance Test for MW System Trial 1

Test Case Name:	MW System Acceptance Test									Date:	11-18-2023
										Time:	1:00 pm
Description:	Checks the interaction between U-Type Tubular heating elements, Exhaust fans, push buttons, relay modules, LCD screen, Thermostat control switch, Thermocouple K-Type sensor, Web camera, GSM module sim900a, Node MCU, and Arduino Uno									Trial No.	1
Action:	Switch on the rocker switch	Place a 5 kilo rice inside the prototype container that infested with a rice weevil with a population of 30 *Sitophilus oryzae*				Press first button	Press second button	Press third button	Control the buttons in a webpage		
Expected Result:	Once rocker switch is on, the system powered up and a dashboard display appear on LCD screen	When first button is pressed, Quick Heating mode will trigger with relay module connected to the heating element and exhaust fan will switch on for 30 minutes	When second button is pressed, Deep Heating mode will trigger with relay module connected to the heating element and exhaust fan will switch on for 60 minutes	When third button is pressed, neiher quick heating or deep heating will stop its process and a dashboard display will appear on LCD screen	SMS message will sent to the coded recipient when the system starts, stops, and completed	SMS Message of "Alert! There is a weevil in the rice" will sent to the recipient when the web camera detects a rice weevil	View a real-time point of view of the web camera where you can see if there is a rice weevil through webpage	The population of *Sitophilus oryzae* will disappear after exposing to extreme heat	Once the deep heating is nearly completed, the system will let you choose if you need to do extra 5 minutes heating. It will proceed for another 5 minutes if you pressed the first button		
Test ID Number:											
1	✓	✓	✓	✓	✗	✗	✓	✓	✓		FAILED
2	✓	✓	✓	✓	✗	✗	✓	✓	✓		FAILED
3	✓	✓	✓	✓	✓	✓	✓	✓	✓		PASSED
4	✓	✓	✓	✓	✓	✗	✓	✓	✓		FAILED
5	✓	✓	✓	✓	✓	✓	✓	✓	✓		PASSED
6	✓	✗	✓	✓	✓	✗	✓	✓	✓		FAILED
7	✓	✗	✗	✓	✓	✗	✓	✓	✗		FAILED
8	✓	✓	✗	✓	✓	✗	✓	✓	✓		FAILED
9	✗	✓	✓	✓	✓	✗	✗	✓	✓		FAILED
10	✓	✓	✓	✓	✓	✗	✗	✓	✓		FAILED
11	✓	✓	✓	✓	✓	✗	✓	✓	✓		FAILED
12	✓	✓	✓	✓	✓	✗	✗	✓	✓		FAILED
13	✓	✓	✗	✓	✗	✗	✗	✓	✓		FAILED
14	✓	✗	✓	✗	✓	✗	✗	✓	✓		FAILED
15	✓	✓	✓	✓	✓	✓	✓	✓	✓		PASSED
Overall Test Result:	FAILED										

Table 4.25 shows the result of integration testing trial 1. The calibration testing was made 15 times conducted at 1:00 pm, November 18, 2023. This trial was marked as FAILED as test id numbers 1, 2, 4, 6, 7, 8, 9, 10, 11, 12, 13, and 14 failed the testing. The system did not switch on when rocker switch is on in test number 9. System did not start it's quick heating when the first button is pressed. Deep heating mode fluctuates when second button is pressed. No SMS messages was sent to the coded recipient that verifies whether the system starts, stops, or completed. Also, no SMS alert system was received when the web camera detects a weevil. The real-time point of view on camera did not appear on the webpage. Lastly, out of 50 pieces of *Sitophilus oryzae* only 41 disappear upon heat process.
Overall, the acceptance testing trial 1 failed the test which gives a 20 % functionality rate. The researchers will proceed to the trial 2.

Table 4.26: Result for Acceptance Test for MW System Trial 2

Test Case Name:	MW System Acceptance Test								Date:	11-30-2023
									Time:	8:00 am
Description:	Checks the interaction between U-Type Tubular heating elements, Exhaust fans, push buttons, relay modules, LCD screen, Thermostat control switch, Thermocouple K-Type sensor, Web camera, GSM module sim900a, Node MCU, and Arduino Uno								Trial No.	2
Action:	Switch on the rocker switch	Place a 5 kilo rice inside the prototype container suspected that is infested with a rice weevil				Press first button	Press second button	Press third button	Control the buttons in a webpage	
Expected Result:	Once rocker awitch is on. The system powered up and a dashboard display appear on LCD screen	When first button is pressed, Quick Heating mode will trigger with relay module connected to the heating element and exhaust fan fan will switch on for 30 minutes	When second button is pressed, Deep Heating mode will trigger with relay module connected to the heating element and exhaust fan fan will switch on for 60 minutes	When third button is pressed, nether quick or deep heating will stop its process and a dashboard display will appear on LCD screen	SMS message will sent to the coded recipient when the starts, stops, and competed	SMS message of "Alert! There is a weevil in the rice" will sent to the recipient when the web camera detects a rice weevil	View a real-time point of view of the web camera where you can see if there is a rice weevil through webpage	The population of *Sitophilus oryzae* will disappear after exposing to extreme heat	Once deep heating is nearly completed, the system will let you choose if you need to do extra 5 minutes heating. It will proceed for another 5 minutes if you pressed the first button	
Test ID Number:										
1	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED
2	✓	✓	✓	✓	✓	✓	✓	✓	✓	FAILED
3	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED
4	✓	✓	✓	✓	✓	✗	✓	✓	✓	FAILED
5	✓	✓	✓	✓	✓	✓	✓	✓	✓	FAILED
6	✓	✓	✗	✓	✗	✓	✓	✓	✓	FAILED
7	✗	✓	✗	✓	✗	✗	✗	✓	✓	FAILED
8	✓	✓	✓	✓	✓	✗	✗	✓	✗	FAILED
9	✓	✓	✓	✓	✓	✗	✓	✓	✓	FAILED
10	✓	✗	✗	✓	✗	✓	✗	✓	✗	FAILED
11	✓	✗	✓	✓	✓	✓	✓	✓	✗	FAILED
12	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED
13	✓	✗	✓	✓	✓	✗	✓	✓	✓	FAILED
14	✗	✓	✓	✓	✓	✗	✓	✓	✓	FAILED
15	✓	✓	✓	✗	✗	✓	✗	✓	✓	FAILED
Overall Test Result:	FAILED									

Table 4.26 shows the result of acceptance testing trial 2. The calibration testing was made 15 times conducted at 8:00 am, November 30, 2023. This trial was marked as FAILED as test id numbers 2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, and 15 failed the testing. The system did not switch on when rocker switch is on in test number 7 and 14. System did not start it's quick heating when the first button is pressed. Deep heating mode fluctuates when second button is pressed. No SMS messages was sent to the coded recipient that verifies whether the system starts, stops, or completed. Also, no SMS alert system was received when the web camera detects a weevil. The real-time point of view on camera did not appear on the webpage. Lastly, out of 50 pieces of *Sitophilus oryzae,* only 46 disappear upon heating process.
Overall, the acceptance testing trial 2 failed the test which gives a 20 % functionality rate. The researchers will proceed to the trial 3.

Table 4.27: Result for Acceptance Test for MW System Trial 3

Test Case Name:	MW System Acceptance Test								Date:	12/12/2023
									Time:	2:00 pm
Description:	Checkas the interaction between U-Type Tubular heating elements, Exhaust Fans, push buttons, relay modules, LCD screen, Thermostat control switch, Thermocouple K-Type sensor, Web camera, GSM module sim900a, NodeMcu, and Arduino Uno								Trial No.	3
Action:	Switch on the rocker switch	Place a 5 kilo rice inside the prototype container suspected that is infested with a rice weevil				Press first button	Press second button	Press third button	Control the buttons in a webpage	
Expected Result:	Once rocker switch is on, the system powered up and a dashboard display appear on LCD screen	When first button is pressed, Quick Heating mode will trigger with relay module connected to the heating element and exhaust fan fan will switch on for 30 minutes	When first button is pressed, Quick Heating mode will trigger with relay module connected to the heating element and exhaust fan fan will switch on for 60 minutes	When third button is pressed, neither quick or deep heating will stop its process and a dashboard display will appear on LCD screen	SMS message will sent to the recipient when the system starts, stops, and completed	SMS message of "Alert! There is a weevil in the rice" will sent to the recipient when the web camera detects a rice weevil	View a real-time point of view of the web camera where you can see if there is rice weevil through webpage	The population of *Sitophilus oryzae* will disappear after exposing to extreme heat	Once deep heating is nearly completed, the system will let you choose if you need to do another 5 minutes of heating. It will proceed for another 5 minutes if you pressed the first button	
Test ID Number:										
1	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED
2	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED
3	✓	✓	✓	✓	✗	✗	✓	✓	✓	FAILED
4	✓	✓	✓	✓	✓	✗	✗	✓	✓	FAILED
5	✓	✓	✓	✓	✓	✗	✗	✓	✓	FAILED
6	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED
7	✓	✓	✗	✓	✓	✓	✗	✓	✓	FAILED
8	✓	✗	✓	✓	✗	✓	✗	✓	✓	FAILED
9	✓	✗	✓	✓	✗	✓	✓	✓	✗	FAILED
10	✓	✓	✓	✓	✓	✓	✓	✓	✗	FAILED
11	✓	✓	✓	✓	✓	✗	✗	✓	✓	FAILED
12	✓	✓	✓	✓	✓	✓	✗	✓	✓	FAILED
13	✓	✓	✓	✓	✓	✗	✓	✓	✓	FAILED
14	✓	✓	✓	✓	✓	✓	✗	✓	✓	FAILED
15	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED
Overall Test Result:	FAILED									

Table 4.27 shows the result of acceptance testing trial 3. The calibration testing was made 15 times conducted at 2:00 pm, December 12, 2023. This trial was marked as FAILED as test id numbers 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, and 14 failed the testing. System did not start it's quick heating when the first button is pressed. Deep heating mode fluctuates when second button is pressed. No SMS messages was sent to the coded recipient that verifies whether the system starts, stops, or completed. Also, no SMS alert system was received when the web camera detects a weevil. The real-time point of view on camera did not appear on the webpage. Out of 50 pieces of *Sitophilus oryzae,* only 48 disappear upon heating process
Overall, the acceptance testing trial 3 failed the test which gives a 26.66 % functionality rate. The researchers will proceed to the trial 4.

Table 4.28: Result for Acceptance Test for MW System Trial 4

Test Case Name:	MW System Acceptance Test								Date:	01-15-2024
									Time:	9:00 am
Description:	Checks the interaction between U-Type Tubular heating elements, Exhaust fans, push buttons, relay modules, LCD screen, Thermostat control switch, Thermocouple K-Type sensor, Web camera, GSM module sim900a, Node MCU, and Arduino Uno								Trial No.	4
Action:	Switch on rocker switch	Place a 5 kilo rice inside the prototype container suspected that is infested with a rice weevil				Press first button	Press second button	Press third button	Control the buttons in a webpage	
Expected Result:	Once rocker switch is on, the system powered up and a dashboard display appear on LCD screen	When first button is pressed, Quick Heating mode will trigger with relay module connected to the heating element and exhaust fan will switch on for 30 minutes	When second button is pressed, Deep Heating mode will trigger with relay module connected to the heating element and exhaust fan will switch on for 60 minutes	When third button is pressed, neiher quick heating or deep heating will stop its process and a dashboard display will appear on LCD screen	SMS message will sent to the coded recipient when the system starts, stops, and completed	SMS Message of "Alert! There is a weevil in the rice" will sent to the recipient when the web camera detects a rice weevil	View a real-time point of view of the web camera where you can see if there is a rice weevil through webpage	The population of *Sitophilus oryzae* will disappear after exposing to extreme heat	Once the deep heating is nearly completed, the system will let you choose if you need to do extra 5 minutes heating. It will proceed for another 5 minutes if you pressed the first button	
Test ID Number:										
1	✓	✓	✓	✓	✗	✓	✓	✓	✓	FAILED
2	✓	✓	✓	✓	✗	✓	✓	✓	✓	FAILED
3	✓	✗	✗	✓	✗	✓	✓	✓	✓	FAILED
4	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED
5	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED
6	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED
7	✓	✓	✓	✓	✓	✗	✗	✓	✓	FAILED
8	✓	✓	✓	✓	✓	✓	✓	✓	✗	FAILED
9	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED
10	✓	✓	✓	✓	✗	✓	✓	✓	✓	FAILED
11	✓	✓	✓	✓	✓	✗	✓	✓	✓	FAILED
12	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED
13	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED
14	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED
15	✓	✓	✓	✓	✓	✗	✓	✓	✓	FAILED
Overall Test Result:	FAILED									

Table 4.28 shows the result of acceptance testing trial 4. The calibration testing was made 15 times conducted at 9:00 am, January 15, 2024. This trial was marked as FAILED as test id numbers 1, 2, 3, 7, 8, 10, 11, and 15 failed the testing. System did not start it's quick heating when the first button is pressed. Deep heating mode fluctuates when second button is pressed. No SMS messages was sent to the coded recipient that verifies whether the system starts, stops, or completed. Also, no SMS alert system was received when the web camera detects a weevil. The real-time point of view on camera did not appear on the webpage. Only 49 pieces of *Sitophilus oryzae* disappear upon heating process

Overall, the acceptance testing trial 4 failed the test which gives a 46.66 % functionality rate. The researchers will proceed to the trial 5.

Table 4.29: Result for Acceptance Test for MW System Trial 5

Test Case Name:	MW System Acceptance Test									Date:	02/07/2024
										Time:	7:00 am
Description:	Checks the interaction between U-Type Tubular heating elements, Exhaust fans, push buttons, relay modules, LCD screen, Thermostat control switch, Thermocouple K-Type sensor, Web camera, GSM module sim900a, Node MCU, and Arduino Uno									Trial No.	5
Action:	Switch on rocker switch	Place a 5 kilo rice inside the prototype container suspected that is infested with a rice weevil				Press first button	Press second button	Press third button	Control the buttons in a webpage		
Expected Result:	Once rocker switch is on, the system powered up and a dashboard display appear on LCD screen	When first button is pressed, Quick Heating mode will trigger with relay module connected to the heating element and exhaust fan will switch on for 30 minutes	When second button is pressed, Deep Heating mode will trigger with relay module connected to the heating element and exhaust fan will switch on for 60 minutes	When third button is pressed, neiher quick heating or deep heating will stop its process and a dashboard display will appear on LCD screen	SMS message will sent to the coded recipient when the system starts, stops, and completed	SMS Message of "Alert! There is a weevil in the rice" will sent to the recipient when the web camera detects a rice weevil	View a real-time point of view of the web camera where you can see if there is a rice weevil through webpage	The population of *Sitophilus oryzae* will disappear after exposing to extreme heat	Once the deep heating is nearly completed, the system will let you choose if you need to do extra 5 minutes heating. It will proceed for another 5 minutes if you pressed the first button		
Test ID Number:											
1	✓	✓	✓	✓	✗	✓	✓	✓	✓	FAILED	
2	✓	✓	✓	✓	✗	✗	✓	✓	✓	FAILED	
3	✓	✓	✗	✓	✓	✓	✗	✓	✗	FAILED	
4	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED	
5	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED	
6	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED	
7	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED	
8	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED	
9	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED	
10	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED	
11	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED	
12	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED	
13	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED	
14	✓	✓	✓	✓	✓	✓	✗	✓	✓	FAILED	
15	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED	
Overall Test Result:	FAILED										

Table 4.29 shows the result of acceptance testing trial 5. The calibration testing was made 15 times conducted at 7:00 am, February 7, 2024. This trial was marked as FAILED as test id numbers 1, 2, 3, and 14 failed the testing. Deep heating mode fluctuates when second button is pressed. No SMS alert system was received when the web camera detects a weevil. And lastly, the real-time point of view on camera did not appear on the webpage.

Overall, the acceptance testing trial 5 failed the test which gives a 73.33 % functionality rate. The researchers will proceed to the trial 6.

Table 4.30: Result for Acceptance Test for MW System Trial 6

Test Case Name:	MW System Acceptance Test								Date:	03-30-2024
									Time:	4:00 pm
Description:	Checks the interaction between U-Type Tubular heating elements, Exhaust fans, push buttons, relay modules, LCD screen, Thermostat control switch, Thermocouple K-Type sensor, Web camera, GSM module sim900a, Node MCU, and Arduino Uno								Trial No.	6
Action:	Switch on rocker switch	Place a 5 kilo rice inside the prototype container suspected that is infested with a rice weevil				Press first button	Press second button	Press third button	Control the buttons in a webpage	
Expected Result:	Once rocker switch is on, the system powered up and a dashboard display appear on LCD screen	When first button is pressed, Quick Heating mode will trigger with relay module connected to the heating element and exhaust fan will switch on for 30 minutes	When second button is pressed, Deep Heating mode will trigger with relay module connected to the heating element and exhaust fan will switch on for 60 minutes	When third button is pressed, neiher quick heating or deep heating will stop its process and a dashboard display will appear on LCD screen	SMS message will sent to the coded recipient when the system starts, stops, and completed	SMS Message of "Alert! There is a weevil in the rice" will sent to the recipient when the web camera detects a rice weevil	View a real-time point of view of the web camera where you can see if there is a rice weevil through webpage	The population of *Sitophilus oryzae* will disappear after exposing to extreme heat	Once the deep heating is nearly completed, the system will let you choose if you need to do extra 5 minutes heating. It will proceed for another 5 minutes if you pressed the first button	
Test ID Number:										
1	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED
2	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED
3	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED
4	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED
5	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED
6	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED
7	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED
8	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED
9	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED
10	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED
11	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED
12	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED
13	✓	✓	✓	✓	✓	✓	✗	✓	✓	FAILED
14	✓	✓	✓	✓	✓	✗	✗	✓	✓	FAILED
15	✓	✓	✓	✓	✗	✗	✓	✓	✓	FAILED
Overall Test Result:	FAILED									

Table 4.30 shows the result of acceptance testing trial 6. The calibration testing was made 15 times conducted at 4:00 pm, March 30, 2024. This trial was marked as FAILED as test id numbers 13, 14. and

15 failed the testing. No SMS alert system was received when the web camera detects a weevil. And lastly, the real-time point of view on camera did not appear on the webpage.
Overall, the acceptance testing trial 6 failed the test which gives a 80 % functionality rate. The researchers will proceed to the trial 7.

Table 4.31: Result for Acceptance Test for MW System Trial 7

Test Case Name:	MW System Acceptance Test									Date:	04-13-2024
										Time:	5:00 pm
Description:	Checks the interaction between U-Type Tubular heating elements, Exhaust fans, push buttons, relay modules, LCD screen, Thermostat control switch, Thermocouple K-Type sensor, Web camera, GSM module sim900a, Node MCU, and Arduino Uno									Trial No.	7
Action:	Switch on rocker switch	Place a 5 kilo rice inside the prototype container suspected that is infested with a rice weevil				Press first button	Press second button	Press third button	Control the buttons in a webpage		
Expected Result:	Once rocker switch is on, the system powered up and a dashboard display appear on LCD screen	When first button is pressed, Quick Heating mode will trigger with relay module connected to the heating element and exhaust fan will switch on for 30 minutes	When second button is pressed, Deep Heating mode will trigger with relay module connected to the heating element and exhaust fan will switch on for 60 minutes	When third button is pressed, neiher quick heating or deep heating will stop its process and a dashboard display will appear on LCD screen	SMS message will sent to the coded recipient when the system starts, stops, and completed	SMS Message of "Alert! There is a weevil in the rice" will sent to the recipient when the web camera detects a rice weevil	View a real-time point of view of the web camera where you can see if there is a rice weevil through webpage	The population of *Sitophilus oryzae* will disappear after exposing to extreme heat	Once the deep heating is nearly completed, the system will let you choose if you need to do extra 5 minutes heating. It will proceed for another 5 minutes if you pressed the first button		
Tesi ID Number:											
1	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED	
2	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED	
3	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED	
4	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED	
5	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED	
6	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED	
7	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED	
8	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED	
9	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED	
10	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED	
11	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED	
12	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED	
13	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED	
14	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED	
15	✓	✓	✓	✓	✓	✓	✓	✓	✓	PASSED	
Overall Test Result:	PASSED										

Table 4.31 shows the result of acceptance testing trial 6. The calibration testing was made 15 times conducted at 5:00 pm, April 13, 2024. This acceptance test checks the interaction between U-type tubular heating elements, exhaust fans, push buttons, relay modules, LCD screen module, Thermostat control switch, Thermocouple K-Type sensor, Web Camera, GSM Module sim900a, Node MCU, and Arduino

Uno. The trial passed the testing which gives an 100% functionality rate. The researchers will proceed to the evaluation process of the prototype,

Table 4.32: Summary Result for Acceptance Test for MW System

Test Case Name:	MW Acceptance Test				
Description:	Checks the interaction between U-Type Tubular heating elements, Exhaust fans, push buttons, relay modules, LCD screen, Thermostat control switch, Thermocouple K-Type sensor, Web camera, GSM module sim900a, Node MCU, and Arduino Uno				
Trial Number:	Pass	Fail	N/A	Date of Testing	Comments
1		×		November 18, 2023	*No SMS notification when the system starts, stops, or completed* *Rocker switch did not respond on test number 9* *First and Second button fluctuates its function and did not display a dashboard on screen when presssed* *Real-time point of view of the camera does not appear on webpage*
2		×		November 30, 2023	*No SMS notification when the system starts, stops, or completed* *Rocker switch did not respond on test number 7, and 14* *First and Second button fluctuates its function and did not display a dashboard on screen when presssed* *Real-time point of view of the camera does not appear on webpage*
3		×		December 12, 2023	*No SMS notification when the system starts, stops, or completed* *First and Second button fluctuates its function and did not display a dashboard on screen when presssed* *Real-time point of view of the camera does not appear on webpage*
4		×		January 15, 2024	*No SMS notification when the system starts, stops, or completed* *No follow-up dashboard diplay occur when deep heating wants to extend fo another five minutes* *First and Second button fluctuates its function and did not display a dashboard on screen when presssed* *Real-time point of view of the camera does not appear on webpage*
5		×		February 7, 2024	*No SMS notification when the system starts, stops, or completed* *No follow-up dashboard diplay occur when deep heating wants to extend fo another five minutes* *Second button fluctuates its function and did not display a dashboard on screen when presssed* *Real-time point of view of the camera does not appear on webpage*
6		×		March 30, 2024	*No SMS notification when the system starts, stops, or completed* *Real-time point of view of the camera does not appear on webpage*
7	✓			April 13, 2024	

Table 4.32 shows the summary result for acceptance testing of MW System. 7 trials were conducted by the researchers and each trials consists of 15 tests. The acceptance test was to verify the overall function of the prototype and checks the interaction between all the components and system that the researchers used. MW System trials 1-6 did not pass the testing. Some errors have been occurring when the researcher conducted trial 1 to trial 6. This includes SMS notification malfunction, LCD screen display not showing variables, and Web camera does not appear on the webpage. These errors have been fixed neither it is hardware or software. Trial 1 and trial 2 gave the least outcome with only 20% functionality rate. Each

trial conducted, the functionality rate increases as trial 3 gave a functionality rate of 26.66%, trial 4 with 46.66%, trial 5 with 73.33% and lastly, 80% for trial 6. Trial 7 passed the testing with a 100% functionality rate. It gives a result where it notifies the user and gives a point of view if there is a weevil on the rice. The system will start neither the first or second button is pressed. Whether it is pressed manually on the prototype or on the website. Once pressed, heating process will start whereas the u-type tubular heater will generate heat. The heat index will regulate at only 65°C. Thermocouple K-type sensor regulates its temperature where it will switch off the u-type heater when temperature exceeds at 65°C and switch on when below 45°C. The system will an SMS notification when the web camera detects a rice weevil. Real-time point of view of the web camera is accessible on a specific webpage where it automatically appears when the system is switch on. Each trial is run with the quick heating that lasts for 30 minutes and deep heating that last up to 60 minutes. A total of 350 pieces of *Sitophilus oryzae* have been tested on heating process. 334 *Sitophilus oryzae* have been eliminated upon 7 trials of acceptance testing. Overall, this trial passed the acceptance testing which gives an excellent functionality rate of 100% that held on April 13, 2024.

A. To test the prototype in terms of Reliability. Functionality, and Durability to its temperature and detecting Sitophilus Oryzae.

Table 4.33 Traditional, Pesticide, and Proposed System Number of weevils eliminated

Trial Number:	Number of weevils eliminated (Pesticide)	Number of weevils eliminated (Traditional)	Number of weevils eliminated (Proposed System)
1	1	10	28
2	0	11	27
3	0	7	29
4	0	8	29
5	0	8	30
6	2	5	27
7	0	13	26
8	1	16	28
9	1	6	29
10	0	3	30
11	2	7	27
12	2	11	26
13	1	10	28
14	1	14	29
15	1	4	30
16	1	9	30
17	0	6	26
18	0	8	24
19	0	4	30
20	2	4	29

21	0	3	26
22	2	7	27
23	1	3	29
24	1	10	30
25	1	15	30
26	0	14	27
27	0	11	29
28	0	9	29
29	0	10	30
30	0	11	29
Total	21	257	848

$$\text{Average weevils eliminated} = \frac{\text{total n of weevils eliminated}}{\text{total n of trials}}$$

This formula determines how much more reliable the automated system compared to the traditional way.
Traditional average weevils eliminated: 8.56
Automated average weevils eliminated: 28.26
Difference = Automated – Traditional
Difference = 28.26 – 8.56
Difference = 19.7 weevils eliminated per trial (30 minutes each trial)

The equation shows the difference of the automated system and the traditional way of removing weevils to the rice and grains. Traditional is averaging 8.56 weevils eliminated per trial with 30-minute duration on each trial. Automated system averaging 28.26 weevils eliminated per trial. The difference is 19.7 weevils eliminated per trial. This improvement impacts the customer satisfaction with a large gap improvement of average weevil eliminated per trial. The reliability of the automated system is undeniable that it can give a much more heat index and remove more weevil population compare to the traditional way in a same amount of time

B. To illustrate the effectiveness of heat as pest control of Sitophilus Oryzae

$$\text{Effectiveness Percentage \%} = \frac{\text{total N of weevils eliminated}}{\text{total N of weevils}} \text{ x } 100$$

$$\text{Pesticide Effectiveness Percentage \%} = \frac{21}{900} \text{ x } 100$$
Pesticide Effectiveness Percentage % = **2.33 %**

$$\text{Traditional Effectiveness Percentage \%} = \frac{257}{900} \text{ x } 100$$
Traditional Effectiveness Percentage % = **28.55 %**

$$\text{Automated Effectiveness Percentage \%} = \frac{848}{900} \text{ x } 100$$
Automated Effectiveness Percentage % = **94.22 %**

Equation shows the total effectiveness percentage of different kind of pest control of *Sitophilus Oryzae.* Pesticide effectiveness percentage gave a low outcome of 2.33%. Pesticide is composed of chemicals that

can kill different types of pests. In this trial, the researchers sprayed a pesticide outside the area of rice container. It sprayed with a distance 24-inch away from the rice container. Pesticide is a chemical and it may be toxic to the rice and it may affect the quality of rice and it can make it inedible due to its toxic contains. Therefore, pesticide is not favourable to the consumer, users, and customers.

Traditional way of eliminating weevils to the rice is putting the rice grains outdoors and give them a direct contact with the sunlight. The heat index of the sunlight can remove the weevils to the infested rice grains. It is the old and common way of the farmers to avoid the infestation of *Sitophilus Oryzae*. The trial gave an outcome of 28.55 %. Unpredictable weather is the main concern on this technique. Sudden rainfall is inconvenient especially for the farmers that producing rice grains.

Automated system gave an excellent outcome of effectiveness percentage. It gave a 94.22 percentage of effectiveness. Each trial is done in the prototype that can be done indoors. Each trial lasted in 30 minutes and produce heat index from 30 to 60 degree Celsius. This way is favourable to the users, consumers, and customer and gave them a convenience of eliminating the weevils indoors. Weather condition is not an issue and it can give a much more heat index than the sunlight can give.

DATA ANALYSIS

After the evaluation of the respondents in the evaluation process, the researchers tallied the data that they gathered using the Likert Scale as seen in table 4. A Likert item is simply a statement that the respondents is asked to evaluate according to any kind of subjective or objective criteria, generally the level of agreement or disagreement is measured. This can help the researchers to determine the capability of the system. The data has to be thoroughly checked to fulfill the strict formal axioms of the project.

Table 4.33: The Likert Scale

Rating	Scale	Range
5	Outstanding	4.51-5.0
4	Above Satisfactory	3.51-4.5
3	Satisfactory	2.51-3.5
2	Below Satisfactory	1.51-2.5
1	Needs Improvement	1.0-1.50

After the acceptance of the new developed system, the implementation phase began. Implementation is the stage of a project in which theory is turned into practice. To be able to check the quality and consistency of the system, the researchers needed an evaluation process. This process helped them determine the weakness of the system. The researcher presented first their project before the evaluation. To determine the weakness and functionality of the project, the researchers conducted evaluation from 30 respondents living in neighborhood, which is Calamba and Tacloban province.

Respondent's type

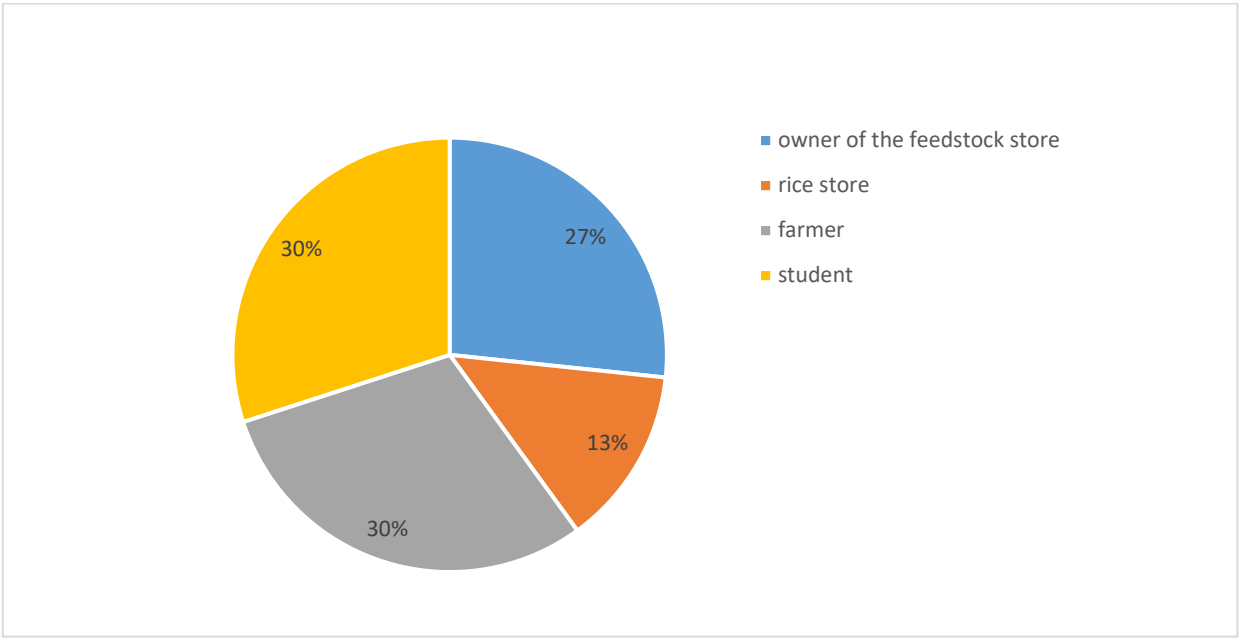


Fig. 4.1 Result of the overall type of respondents'

Shows the pie graph on what type of respondent the researchers have. On the total of 30 respondents, 27% (8) are the owner of the feedstock store, 13% (4) from the rice store and, 30% (9) are from the farmers and lastly, the other 30% (9) are from students.

Functionality Statistics

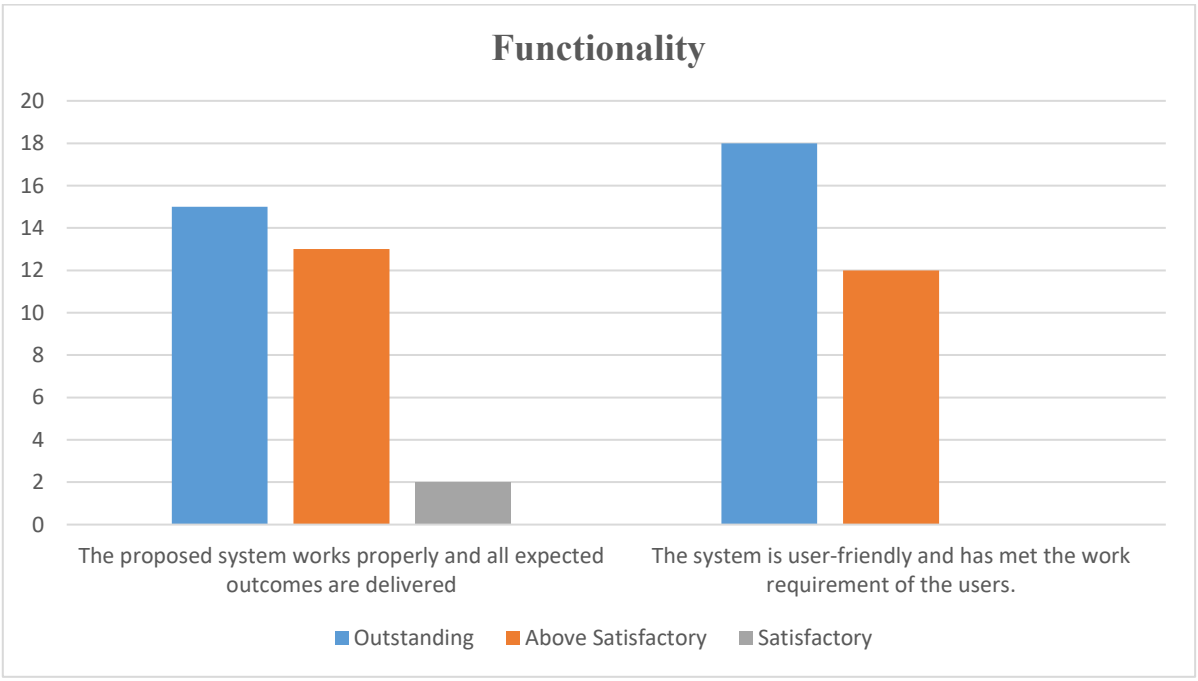


Fig. 4.2 Functionality

Shows the result on functionality of the system. The first indicator is if the proposed system works properly and all expected outcome are delivered. On 30 respondents, 15 responded outstanding, 13 on above satisfactory and 2 on satisfactory. Using the Likert Scale computation:

Sentiment Level	Rating	Response	Total
Outstanding	5	15	75
Above Satisfactory	4	13	52
Satisfactory	3	2	6
Below Satisfactory	2	0	0
Need Improvement	1	0	0
Range is (75+52+6)/30			4.43 *Above Satisfactory*

The second indicator is if the proposed system works properly and all expected outcome are delivered. On 30 respondents, 18 responded outstanding, and 12 on above satisfactory. Using the Likert scale computation:

Sentiment Level	Rating	Response	Total
Outstanding	5	18	90
Above Satisfactory	4	12	48
Satisfactory	3	0	0
Below Satisfactory	2	0	0
Need Improvement	1	0	0
Range is (90+48)/30			4.6 *Outstanding*

To calculate the average of the 2 evaluation for functionality: (range1+range2)/2=functionality range, thus (4.43+4.6)/2= 4.51 giving a sentiment level for the system functionality outstanding.
(Eq. 4.1)

Reliability Statistics

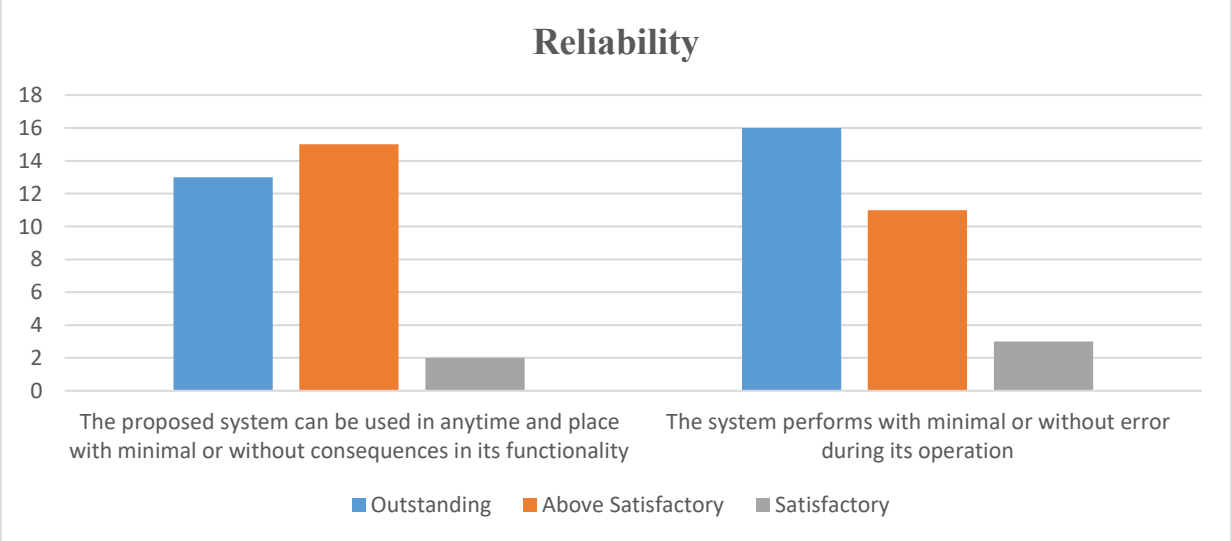


Fig 4.3 Reliability

Shows the result on reliability of the system. The first indicator is if the proposed system can be used in any time and place with minimal or without consequences in its functionality. On 30 respondents, 13 on outstanding, 15 on above satisfactory and 2 on satisfactory.

Sentiment Level	Rating	Response	Total
Outstanding	5	13	65
Above Satisfactory	4	15	60
Satisfactory	3	2	6
Below Satisfactory	2	0	0
Need Improvement	1	0	0
Range is (65+60+6)/30			4.36 *Above Satisfactory*

The second indicator is if the system performs with minimal or without errors during its operations. On 30 respondents, 16 responded on outstanding, 11 on above satisfactory, and 3 on satisfactory.

Sentiment Level	Rating	Response	Total
Outstanding	5	16	80
Above Satisfactory	4	11	44
Satisfactory	3	3	9
Below Satisfactory	2	0	0
Need Improvement	1	0	0
Range is (80+44+9)/30			4.43 *Above Satisfactory*

To calculate the average of the two (2) evaluation for reliability: (range1+range2)/2= reliability range, thus (4.36+4.43)/2= 4.39 giving the sentiment level for the system reliability of above satisfactory. *(Eq. 4.2)*

Durability Statistics

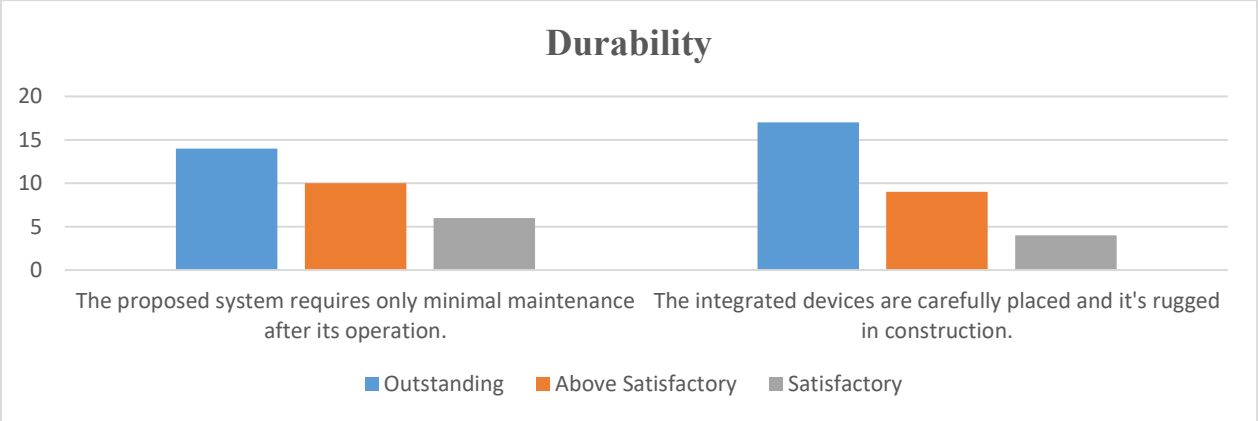


Figure 4.4 Durability

Shows the result on Durability of the system. The first indicator is if the proposed system requires only minimal maintenance after its operation. On 30 respondents, 14 responded on outstanding, 10 on above satisfactory, and 6 for satisfactory. Using the Likert scale computation:

Sentiment Level	Rating	Response	Total
Outstanding	5	14	70
Above Satisfactory	4	10	40
Satisfactory	3	6	18
Below Satisfactory	2	0	0
Need Improvement	1	0	0
Range is (70+40+18)/30			4.26 *Above Satisfactory*

The second indicator is if the system is in rugged construction. On 30 respondents, 17 responded for outstanding, 9 for above satisfactory and 4 on satisfactory. Using the Likert scale computation:

Sentiment Level	Rating	Response	Total
Outstanding	5	17	85
Above Satisfactory	4	9	36
Satisfactory	3	4	12
Below Satisfactory	2	0	0
Need Improvement	1	0	0
Range is (85+36+12)/30			4.43 *Above Satisfactory*

To calculate the average of the 2 evaluation for Durability: (R1+R2)/2= durability range, thus (4.43+4.26)/2= 4.34 giving a sentiment level for the system durability of Above Satisfactory.
(Eq. 4.3)

Extensibility statistics

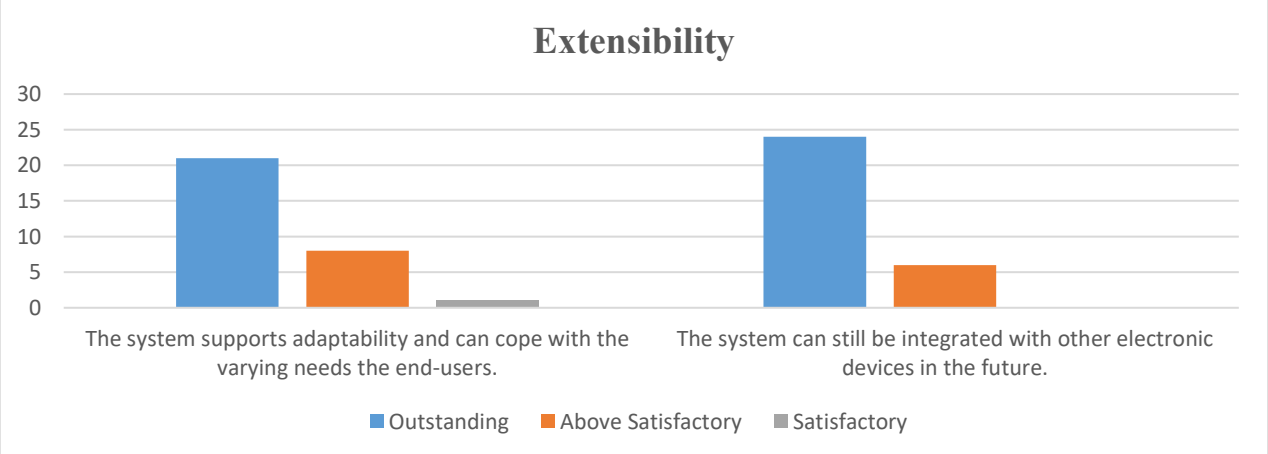


Fig. 4.5 Extensibility

Shows the result on Extensibility of the system. The first indicator is if the proposed system supports adaptability, coping with the needs of the end-user. On 30 respondents, 21 responded on outstanding, 8 for the above satisfactory and 1 on satisfactory. Using the Likert scale computation:

Sentiment Level	Rating	Response	Total
Outstanding	5	21	105
Above Satisfactory	4	8	32
Satisfactory	3	1	3
Below Satisfactory	2	0	0
Need Improvement	1	0	0
Range is (105+32+3)/30			4.66 *Outstanding*

The second indicator is if the system can still be integrated with other devices in the future. On 30 respondents, 24 responded for the outstanding and 6 for above satisfactory. Using the Likert scale:

Sentiment Level	Rating	Response	Total
Outstanding	5	24	120
Above Satisfactory	4	6	24
Satisfactory	3	0	0
Below Satisfactory	2	0	0
Need Improvement	1	0	0
Range is (120+24)/30			4.8 *Outstanding*

To calculate the average of the 2 evaluation for Extensibility: (R1+R2)/2= Extensibility range, thus (4.66+4.8)/2= 4.79 giving a sentiment level for the system extensibility of Outstanding.
(Eq. 4.4)

Economic Feasibility Statistics

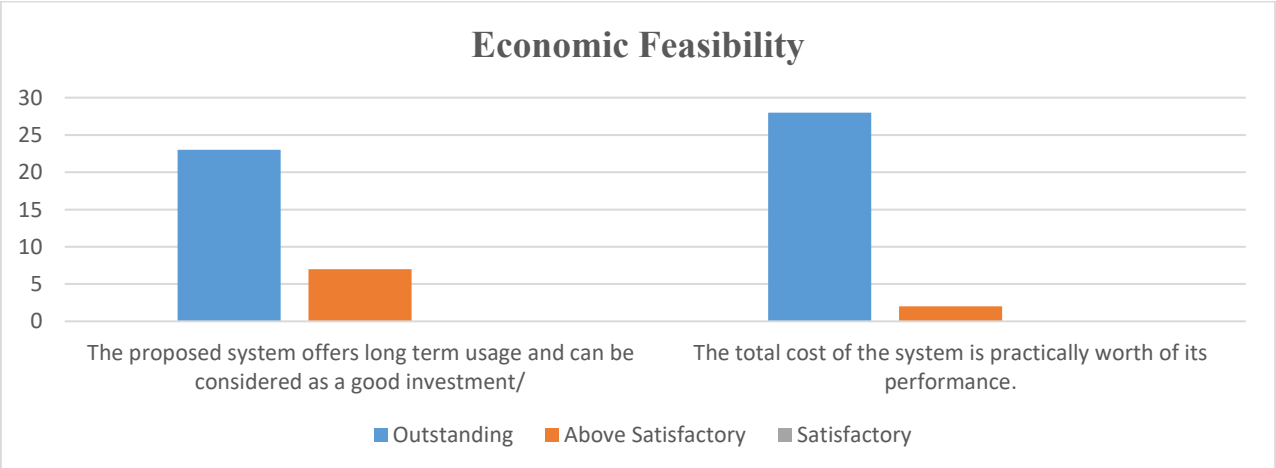


Fig. 4.6 Economic feasibility

Shows the result on economic feasibility of the system. The first indicator is if the proposed system offers long-term usage and can be considered as a good investment. On 30 respondents, 23 responded outstanding and 7 on above satisfactory. Using Likert scale computation:

Sentiment Level	Rating	Response	Total
Outstanding	5	23	115
Above Satisfactory	4	7	28
Satisfactory	3	0	0
Below Satisfactory	2	0	0
Need Improvement	1	0	0
Range is (115+28)/30			4.76 *Outstanding*

The second indicator is if the total cost of the system is a practically worth of its performance. 30 respondents, 28 responded outstanding and 2 on above satisfactory. Using the Likert scale computation:

Sentiment Level	Rating	Response	Total
Outstanding	5	28	140
Above Satisfactory	4	2	8
Satisfactory	3	0	0
Below Satisfactory	2	0	0
Need Improvement	1	0	0
Range is (140+8)/30			4.93 *Outstanding*

To calculate the average of the 2 evaluation for economic feasibility: (R1+R2)/2= economic feasibility range, thus (4.76+4.93)/2= 4.84 giving a sentiment level for the system economic feasibility of Outstanding.

(Eq. 4.5)

Overall, for the five (5) objectives, the calculation for the sentiment level on the system evaluation is a s follow: (Functionality + Reliability + Durability + extensibility + economic feasibility)/5 = System's sentiment level.

Thus, (4.51 + 4.39 + 4.34 + 4.79 + 4.84)/5 = 4.57 giving the whole system's sentiment level or Scale of Outstanding.

CHAPTER V
SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

This chapter provides three important aspects of the study. First, it summarizes the results obtained in the previous chapter. Second, it draws conclusions based on the results. Third, it suggests a set of recommendations that could be used to improve the design project further.

5.1 Summary of Findings

The goal of the study was to create a monitoring device that could monitor and detect the *Sitophilus Oryzae* in real-time viewing by using deep learning in technology. The system was developed using an Arduino UNO, Node MCU, web camera, heating element and other components to enable the real-time viewing analytics and notify the user. The web camera was implemented in Arduino UNO to analyze and detect the S. Oryzae. Also, the heating element implemented in Arduino with a set of timer for quick and deep heating when it's operates. The system was designed using a modular architecture for easy maintainability and economic feasibility. Integration, acceptance and, unit test was conducted on recognition and detection of *Sitophilus Oryzae* which it can analyze and notify the user by sending a SMS successfully. 30 survey respondents evaluated the system's functionality, reliability, durability, extensibility and, economic feasibility. Based on the respondent evaluation using the Likert scale computation. The functionality of the project system gave a 4.51 rate, giving the scale of outstanding level. The people who participated on this study found that the proposed project system functions correctly, achieved all the expected results, it's easy to use and fulfill the user needs. The second criterion is reliability which gave a 4.39 rate, giving the scale of Above Satisfactory level. They observed that the proposed project system can be use at any time and location with a little no to its functionality. Moreover, the project system operates with minimal to no errors during its operations. The third criterion is durability which also gave a 4.34 rate, giving the scale of Above Satisfactory level. They noted that the proposed project system needs a very little maintenance after it has been used. The fourth criterion is extensibility has a 4.79 rate, giving the scale of outstanding level. They identified that there's a part of the project system that can be enhance or develop for the next future researcher. The last criterion is economic feasibility which gave a 4.84 rate, giving the scale of outstanding level. They observed that the proposed project system provides prolonged utility and can be viewed as a worthwhile investment. Furthermore, the overall cost of the system is justified by its performance. Overall, the proposed project system has been evaluated to be in outstanding level as the respondents rate it to an average of 4.57.

5.2 Conclusion

The integration of web camera is for dark object detection. A real-time point of view of camera can be viewed through a webpage and the integration of thermal heating element instead of using the solar heat index to create heat temperature. Additionally, the creation of a website is included in the system for real-time viewing. This innovative approached leverage a modular hardware and software architecture, establishing a robust framework for preventing a loss of quality when it comes to foods and to ensure the safeness. The project has not only showcased compelling proof of concept but has also underscored its ability to promptly notify the user upon monitoring and detecting the S. Oryzae. The impressive accuracy demonstrated in identifying dark objects while doing the heating phase at the same time on rice weevil (*Sitophilus Oryzae*) further validates the practicality of deep learning models like webcam and thermal heating device within the realm of web applications. The effectiveness of heat as a pest control on this specific pest called *Sitophilus oryzae* is very favorable and reliable. Generating a heat into a prototype that is comparable to the heat index of sunlight is convenient in indoor use to avoid infestation. The overwhelmingly positive response received regarding the proposed project system's functionality and user-friendliness underscores its effectiveness in preventing the infestation of the products for safety.

5.3 Recommendations

The study recommends the following:

- A larger container that can hold up to 25 kilograms of the rice as it only a maximum of 5 kilograms

- Attachment of a filtration system where it can automatically separate the weevils to the Rice, feeds, and other wheat products
- Improving the web application into a mobile application for more convenience
- Upgrading the web application where you can adjust the prototype heat temperature
- A reserve power supply of the system as it only powered by a 5v power supply
- Expanding the detection of *Sitophilus oryzae* so it can use on all variety of rice, feeds, and other wheat products

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