Insect and Pest Identification Repellent System in Warehouses Utilizing EMF Radiation and Ultrasound Emission

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ABSTRACT

This project proposes an innovative solution for insect and pest management in Warehouses by combining advanced technologies. The system employs an ESP32 camera for visible pest detection such as Rodents, Mice's, Birds, and Squirrels, utilizing a Deep Learning Convolutional Neural Network (CNN) model. Upon identification, a corresponding sound frequency is emitted through a frequency generator controlled by a Node MCU microcontroller. For invisible pests, continuous electromagnetic field (EMF) radiation is emitted to serve as a repellent. The integration of EMF radiation and ultrasound emission provides a comprehensive approach to pest control, offering both detection and deterrent capabilities. This system leverages the power of IoT and artificial intelligence, providing an efficient and sustainable solution for pest management in various environments. The proposed technology holds promise for environmentally friendly pest control methods with potential applications in agriculture, urban settings, and beyond.

Keywords: *EMF, Ultrasound, pest, Repellent System, Rice Weevils.*

1. Introduction

Post-harvest loss in India refers to the reduction in quantity and quality of food crops after harvesting and before reaching the consumer. It occurs due to inadequate storage facilities, improper transportation, and lack of processing infrastructure. Factors such as poor handling, pest infestation, and climatic conditions contribute to significant losses in crops like grains, fruits, and vegetables.

Storage plays a very important role in losses. In many places, crops are grown seasonally and following harvesting, grains are stored for short or long periods as food reserves and seeds for the next season. It has been reported that in developing countries like India approximately 50% - 60% of the grains are stored in traditional storage structures.

Damage of stored food grains is very serious problem in South-East Asia and throughout the globe. Due to lack of proper ware housing facilities, stored grain largely damages food grains in stores as well as during shipping and transportation, Example high amount of maize is wasted after 90 days of storage. Infestation of stored grains is a very important issue because different stages of the life cycle of insects affect the economy and lower the quality of food grains and food products.

Due to uncontrolled weather circumstances and inadequate ware housing technology, a significant amount of stored grain insect pests causes food grains in farmer stores and public ware houses to become infested. Nonetheless, more targeted, and more suitable modern measures should be employed to restrict the expanding insect population.

Some of the main techniques that have proven very successful against stored grain insects include the use of entomopathogens, pheromone-tipped traps, microwave and ionizing radiation, and IGRs. Control agents and oocyst inhibitors isolated from different plant species are believed to be much safer than those methods compared to synthetic insecticides. These organic pesticides break down naturally and have no negative side effects. Instead, non-residual, non-persistent and less dangerous bio-organic pesticides that may not degrade food should be used. In addition, low pressure and low temperature treatments have been shown to be significantly safer pest control methods and could be used instead of fumigants to control butterflies and moths**.**

2. REVIEW OF LITERATURE

A. STORAGE LOSSES

From the standing crop in the field to several stages of grain processing and storage, stored product pests get access to grain storage. While over one thousand bug species have been linked to stored goods globally, some pests are thought to be inflicting serious harm to the grains that are being stored. Based on their feeding habits, stored grain insect pests can be classified as major or minor pests according to the extent of the damage they cause, or as internal and exterior feeders.

B. STORGAE OF GRAINS

a) Rice Storage

In India, rice is stored using a variety of techniques, such as modern facilities like silos, conventional granaries or warehouses, and in certain rural regions, household storage. To provide food security, the government also runs Public Distribution System (PDS) warehouses.
Given that rice is a major staple grain in India, proper storage is essential to preventing spoiling from pests, moisture, or temperature variations.

Approximately 93 million tons, or one-fifth of the world's production, of rice are produced in India. India is the world's second-largest producer of rice. Over 200 commercial indica subspecies rice varieties are cultivated on approximately 45 million hectares of land, with 25 percent of that area being irrigated. The yield is 2,086 kg ha–1 on average (FAI 2003).

In India, more workers are employed in the rice industry than in any other. For their personal use and as seed, farmers keep about two thirds of the production. About 10% of the world's rice supply is processed into foods like beaten rice, puffed rice, and puffed paddy; other foods include fermented foods like idli, dosa, and uthapam, as well as deep-fried foods like papads and chakli.

b) Wheat Storage

One of the most significant cereal crops in the world is maize. With its wide range of adaptability, it is among the most versatile emerging crops. A variety of conditions can be used to grow maize crops. Because of its potential for the highest genetic yield, maize is also referred to as the "queen of cereals."

In India, maize (Zea mays L.) is a commodity with significant economic value. Its production and demand are rising faster than those of other major commodities. 50 million metric tonnes (MMT) of maize grain are predicted to be needed by India by 2025; of these, 32 MMT would be needed for feed, 15 MMT for industry, 2 MMT for food, and 1 MMT for seeds and other uses. There would also be a potential for exports of roughly 10 MMT above this.

In order to increase productivity, technological interventions such as cultivar diversification and development, stress resilience incorporation in the germplasm, new tool-accelerated breeding processes, and adoption of contemporary cultivation and protection techniques, such as conservation agriculture technologies, would be crucial. In addition, policy interventions such as bolstering value chains, price stabilisation mechanisms, post-harvest handling infrastructure, extension system streamlining, hybrid seed delivery mechanisms augmentation, appropriate policy on genetically modified seeds, etc., will be crucially needed.

c) Maize Storage

Today, wheat is a major food staple in India and is essential to the country's food security and economy. India has the second-largest wheat economy in the world, with production of 70–75 million tonnes and a high demand. The economy, government budgets, consumer welfare, and farmer incomes all depend heavily on marketing efficiency. There are significant alterations occurring in the wheat marketing sector.

There are wide regional variations in the demand for wheat among consumers. However, wheat has become more widely consumed in the south and east. Retailers maintain a variety of wheat and wheat products because they are becoming more aware of customer demand and quality.

C. PEST

a) (Rice weevils)

Rice weevils, both large and small, are separate, reproductively isolated species. For the former, the name Sitophilus oryza (L.) is appropriate, and for the latter, S. sasakii (Tak.). Both species have varying coloring, overlapping measurements, and no discernible external physical differences; nonetheless, the female's eighth sternum and the male's sclerite on the dorsal surface of the aedeagus differ.

The highest rate of reproduction for both species was seen in grain sorghum, followed by rough rice and maize (corn).The fertility rate of eggs laid is about 90%. Usually, cannibalism destroys all other individuals in a grain, leaving only one adult to mature. The ratio of sexes is one. Crossing C. granaria with C. oryzae was not feasible.

Relative humidity influences the daily oviposition rate of C. oryzae at 17, 21, and 25° C. A critical point is reached at roughly 60% r.h. below which there is a sharp drop in egg laying and a significant mortality rate. At 17, 21, and 25° C, the oviposition rates per female per day at 100% r.h. are roughly 1.3, 2.5, and 3.4.

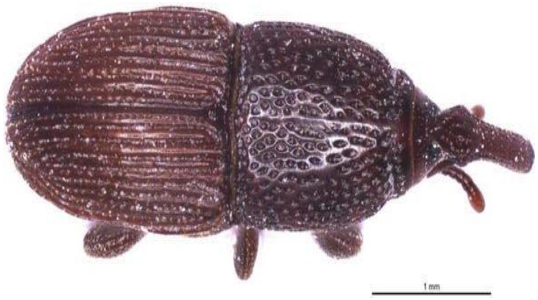

Fig C.1 Rice Weevils - ***Sitophilus oryza***

b) ***(Wheat Weevils)***

The wheat weevil, also known as the grain weevil or granary weevil, is an insect that feeds on cereal grains, causing significant damage to stored grains and reducing crop yields by laying many eggs, with the larvae eating the inside of the grain kernels. Wheat weevils (Sitophilus granarius) are tiny, reddish-brown beetles that infest stored grains, especially wheat, and are prevalent in both grain storage facilities and household pantries. These pests lay eggs inside wheat kernels, and when the eggs hatch, the larvae consume the inner parts of the grains. This feeding behavior can diminish the quality and quantity of stored grains, resulting in substantial economic losses. Effective management of wheat weevil infestations requires preventative actions like maintaining proper storage hygiene and controlling temperature levels.Wheat weevils can cause significant harm to wheat crops, especially when they infest stored grains. They lay their eggs inside the wheat kernels, and the hatched larvae feed on the internal parts of the grain, reducing its quality and nutritional value. This feeding activity can lead to a decrease in crop yields and can render the affected wheat unusable for human or animal consumption. Preventative measures and proper storage practices are important to avoid or minimize damage from wheat weevils.

Fig C.2 ***Wheat Weevils - Sitophilus Granarius***

c***)*** **(Lessser Grain Borer)**

Cereal grains like rice, corn, and wheat serve as the main sources of dietary energy in the majority of nations. Insects that feed on stored goods, like Rhyzopertha dominica, the lesser grain borer, are very likely to infest these grains. A common insect pest of raw grains that is kept in storage is Rhyzopertha dominica. This species can easily spread from one storage facility to another and start new infestations because it is well suited to dry conditions and is thought to be a strong flyer. Grain kernels are covered in eggs laid by females, which hatch into larvae that live inside the kernels until they reach adulthood. As the developing larva feeds inside the kernel, the endosperm and germ suffer damage and the larva loses weight. The fully grown adult leaves the kernel by boring a sizable exit hole, giving rise to what is known as an insect-damaged kernel (IDK) in wheat. Therefore, internal and external feeding by larvae and mature adults adults causes significant physical damage and weight loss.

Fig C.3 ***Lessser Grain Borer*** **- Rhyzopertha dominica**

D. PEST CONTROL MANAGEMENT

Physical control techniques include impact, desiccation, physical exclusion, removal, and ionizing radiation. These techniques are used to change environmental parameters like temperature, relative humidity, and atmospheric composition.
Temperature:

a) Temperature Tolerance

Temperatures between 20 and 14°C will cause an increase in the number of stored pests. Pests die when temperatures are dropped below 14°C, when temperatures are brought below their freezing point, such as -10 to -20°C, they die rapidly, and when temperatures are raised to 40 to 65°C, they perish immediately. Management strategies for control of stored grain insect pests in farmer stores and public ware houses.

b) Pest Control Treatments

People are encouraged to switch to non-chemical treatments like aeration cooling from chemical treatments like spinosad, which is used as a grain protectant, and sulfuryl fluoride, which is used as a grain fumigant.

Fumigation and grain protection are two common strategies used to manage pests, however, because of their adverse effects, people are turning to safer alternatives, such as Pulegone, a natural pest managing agent that is incorporated into coarse and nano emulsions. Emulsion-based formulation is more beneficial as, according to a study, it kills 90% of Riceweevils (Sutophilus oryzae L) and red flour beetles (Tribolium castaneum Herbst). Coarse and nano emulsions are used for effective delivery of the natural pest control agent "pulegone" for protection stored grain.

E. PEST IDENTIFICATION

a) Methodology

Entomologists define pest management as eliminating pests that have the least negative effects on people and the environment, in order to do so, nowadays infusion of technology such as EMP and RF Technologies on pest control in Warehouses and Storage Granaries are greatly welcomed.

Wireless cameras are used to catch the pests, after which the image is further processed and analyzed to produce an improved structure. The pest is then identified by comparing the reference image with the base image. The pest is then examined after being filtered and extracted. The CNN algorithm is used overall.

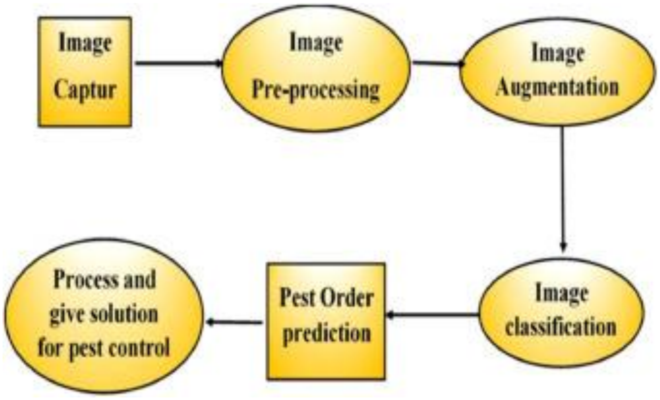

Fig E.1 Algorithm of Pest Identification

F. PROPERTIES USED

a) EMF

In addition to being safer options to potentially harmful methods like using pesticides or hot air to manage pests, EMF, ultrasonic, and sonic devices are important tools in the fight against pests and rodents. The dielectric characteristics of pest and matrix materials are different, which sets electromagnetic heating techniques apart from other forms of thermal conduction. A radiofrequency of 27.12 MHz at 70°C for 150 seconds fully regulated C. Cephalonica in milled rice, R. Dominicica in paddy rice in 180 seconds, and S. Oryzae at 50°C for 15 minutes. Treatment choices are based on a number of factors, including cost, complexity, availability, and other limitations. Fire, water-based and atmospheric heat, steam, vapor heat, dry heat, forced hot air, high temperature controlled atmospheres, electric fields, and electromagnetic energies are some of the ways that heat can be employed independently or in combination.

b) Radio Frequency

RF applications have been successfully induced in a variety of industries, including plastic, welding, plywood curing, textile drying, and drying bakery items. There has been recent research on the use of RF on post-harvest agricultural products for disinfections; however, in an ideal scenario, this method would not impact the quality of the product and would need to be feasible as well as offer sufficient mortality.

One of the main issues with radiofrequency (RF) is its non-uniformity, which can cause damage to products and allow pests to survive. To combat this, samples are surrounded by dielectric material and heated with hot air or water. According to RF research on walnuts, it causes a temperature increase of 53 to 55°C, which kills the pests.The process by which radiofrequency (RF) creates "dielectric Heating" involves creating friction between the molecules of water, resulting in the creation and storage of electric energy that turns into thermal energy.

Two ideas that are thought to be crucial for disinfecting insects include selective heating as well as dielectric heating. Using a dielectric, RF and MW may heat moist materials like bugs and host materials. This also depends on the materials' thermal characteristics and the strength of the electric field. The non-contact, volumetric, and delayed heating properties of RF and MW are their advantages.

c) Ultrasound

Initially, high-intensity ultrasound (20 KHZ, 130 db at 1 m) rejected rats and mice. For several days, rats in the warehouse were resisted but not driven out. Frings (1948). Recommended sound level for wild rodents above 20 kHz. According to a paper, the built-in ultrasonic repelled producing frequencies of 35, 38, 40, and 50 kHz are repelled away.

Eventually, the confined rodents demobilized them when they got close. Many sonic/ultrasonic, electromagnetic, mechanical/vibrational, and electrical barriers have been tested and released onto the market within the past 30 years. Even a Bluetooth-enabled rat trap has been developed that employs ultrasonic waves to snare rats and mice via a smartphone app. The trap is primarily automated and notifies the rat when it has been trapped.

3. DEVICE METHODOLOGY:

The studies' primary goal is to develop a device including an ESP Camera, and an EMF and Ultrasound Circuit, working under a connected power source and node MCU for monitoring over the pest identification and producing the result which is the Repulsion of Rodents and Mice through Ultrasound and Resultant Mortality of the Insects such as Rice Weevils on the stacked Grains.

The Device Design is Explained through a Circuit Diagram

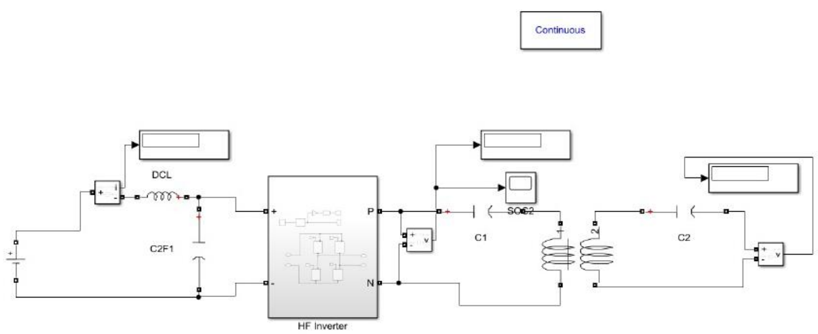

Fig 3.1 Circuit Diagram of the Device

- NodeMCU: Provides Wi-Fi connectivity and acts as a microcontroller for IoT applications, enabling communication with other devices and servers.
- ESP32-CAM: Integrates Wi-Fi and camera functionality, allowing for wireless image/video capture and transmission in IoT projects, surveillance systems, and more.
- SMPS (Switched-Mode Power Supply): Converts AC power to DC power efficiently, providing stable and regulated power to various components within the device.

- DC to DC Converter: Converts one DC voltage level to another, ensuring compatibility between different components with varying power requirements.
- EMF and Ultrasound Circuit: Detects electromagnetic fields (EMF) and ultrasound signals, used in various applications such as proximity sensing, object detection, and medical imaging.

- HF Inverter: Converts DC power to high-frequency AC power, commonly used in applications such as solar power systems, electric vehicles, and uninterruptible power supplies (UPS).

4. CONCLUSION

The current paper summaries the substantial research efforts and findings on the usage of ultrasonic sound frequency and radio frequency equipment for pest control management in the stored grains. Future scholars as well as those who build alternative machines will find values in the information gained in this work. These technologies offer non-toxic and environmentally friendly alternatives to traditional pest management methods. Overall, the integration of these systems into pest management strategies has the potential to significantly improve pest control practices while minimizing environmental impact.

5. REFERENCES

[1]. A Kalleta, K. G. (2013). Criteria of determination of safe grain storage time–A review. *Advances in agrophysical research , .*

[2]Chndrasen Kumar, C. R. (2021). Warehouse storage management of wheat and their role in food security. *Fronteirs in Sustainable Food Systems 5, 675626,* .

[3]Darka Hamel, V. R. (2020). Storage of Cereals in Warehouses with or without Pesticides, . *Insects 11 (12), 846,* .

[4]Gilad Golden, E. Q. (2017). Coarse and Nano emulsions for effective delivery of the natural pest control agent Pulegone for stored grain protection .

[5]Gregory J Daglish, M. K. (2018). Insect pest management in stored grain . *Recent advances in stored product protection, 45-63* .

[6]J Joselin Jeya Sheela, M Logeshwaran, Shaik Saida, DJ Subhashini, K Sivasambavi, R Shalini. (2023). . Design of Rat Trap based on Ultrasonic Waves using Bluetooth Technology. *2nd International Conference on Applied Artificial Intelligence and Computing (ICAAIC),* .

[7] L Hou, J. J. (2016). Radio frequency heating for postharvest control of pests in agricultural products: A review. *Post Harvest Biology and Technology* .

[8] Ravi Kant Upadhyay, S. A. (2011). Management strategies for control of stored grain insect pests in farmer stores and public ware houses. *World Journal of agricultural Sciences 7(5), 525 - 549,* .

[9] Radio frequency and microwave alternative treatments for insect control in nuts: a review
S Wang, J Tang Agricultural Engineering Journal 10 (3&4), 105-120, 2001

[10] Disinfestation of insect pests in stored agricultural materials using microwave and radio frequency heating: A review RJ Macana, OD Baik Food reviews international 34 (5), 483-510, 2018

[11]Rajendr, S. (2020). .A review of grain storage systems and the impact of time, temperature, and moisture on grain quality Insect pest management in stored productsr 2020. *anOutlooks on Pest Management 31 (1), 24-35,* .

[12]RJ Macana, O. B. (2018). . Disinfestation of insect pests in stored agricultural materials using microwave and radio frequency heating: A review. *Food reviews international 34 (5), 483-510,* .

[13]S Wang, J. T. (2001). Radio frequency and microwave alternative treatments for insect control in nuts: a review . *Agricultural Engineering Journal 10 (3&4), 105-120,* .

[14]Schumake, S. A. (1995). Electronic rodent repellent devices: a review of efficacy test protocols and regulatory actions. *Wildlife Research Centre Repellants Conference 1995, 34* .

[15] Pest control management system using organic pesticides NOV 2021Author lPramoda Kalkura, Puneeth Raj B, Suhas Kashyap N, Surya, Ms. Ramyashree.

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