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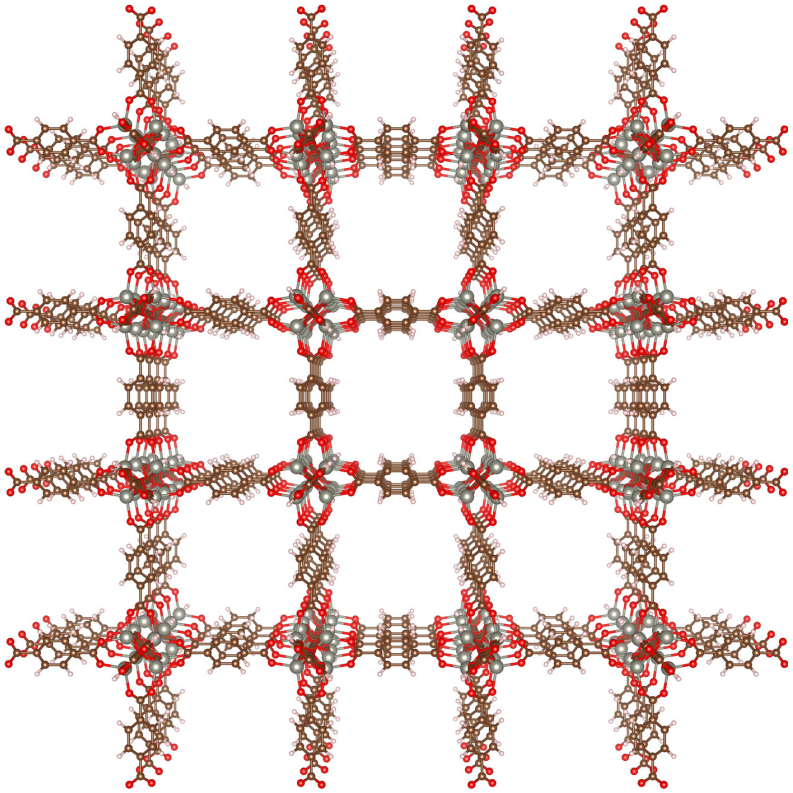

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Cover: Ball-and-stick model of MOF-5. © Roshani Sharma. Printed with permission.

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Himalayan Physics

Controlling pests in post-harvested wheat using microwave heating

Research Article

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Abstract: Microwaves refer to electromagnetic waves ranging from 300 MHz to 300 GHz in frequencies. Microwave de-infestation works well without degrading the host material's quality. In this research, four different samples of wheat grains are taken from each location, which are injected by 20 pests of the same type per sample. Each sample is then put into the microwave oven for the exposure time of 1 minute and 30 seconds, heated at temperatures 60°C, 70°C, 80°C, 90°C, and 100°C. Finally, the samples are germinated, followed by the analysis of nutrition levels at the laboratory. The statistical analysis of the data shows a significant difference in mortality and germination with temperature changes. The average mortality rate was 95% at 100°C for 1 min of exposure time, exposing mortality increases with temperature. The germination decreased with the temperature increment and the exposure time magnitude. Statistical analysis reveals that there is no significant difference in the nutrition levels of wheat with the temperature change. The study concludes that microwave heating is one of the effective tools for controlling pests in post-harvested grains without using pesticides.

Keywords: Germination • Grains • Microwave heating • Nutrition • Pests • Temperature

I. Introduction

Pests are any animals or plants that cause harm to people or human concerns, including livestock, forestry, and agricultural products. One-quarter of the annual grain crop in the globe is thought to be lost in storage. Insect attacks are the primary cause of this. Most grain pests prefer to eat grain embryos, lowering feed grain's protein content and the percentage of germinating seeds [1].

The five primary insects that attack stored grains are Granary weevil, Rice weevil, Maize weevil, and Grain borer [1]. Angoumois grain moth spoils wheat and corn. Other insects found in stored grains are beetles, moths, and mealworms. Fewer grain borers mainly attack wheat, corn, rice, and millet. Both larvae and adults are primary pests [2, 3]. Insects pierce unbroken, irregularly shaped cavities. Unharmed nuclei, larvae, and the immature stage may develop inside the seed. Larvae and adults feeding on grains may leave dust and little, brown husks behind. From March through November, this species breeds, and in December, it hibernates as an adult or a larva [2]. This bug invasion is frequently linked to the sweet, musty fragrance. Additionally, the seeds

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are harmed by a homogeneous grain moth. This pest is most prevalent in mountainous regions or places with a mild climate. It mainly damages grains like rice, wheat, corn, sorghum, barley, and oats from April to October; when spawning occurs [4]. The insect pupates in the early spring after spending the entire winter hibernating larvae. The monsoon season is when the devastation is the most severe. Only the larva devours the seeds, causing damage before and after harvest. The larvae eat the seed's contents after tunnelling into it. Drainage holes 1 mm in diameter, with or without traps, have been detected on affected wheat grains. It will expand the hole and partially fill it with pellets as it grows. In many cases, the top layers of the grains are badly impacted.

Microwave heating method

Microwaves are a form of "electromagnetic" radiation, with frequency ranges from 300 MHz to 300 GHz. Industry uses microwaves to dry and harden plywood, harden rubber and plastic, make bread and doughnuts, and cook potato chips [5, 6]. It has been demonstrated that microwave disinfestation is effective without compromising the quality of the host materials [7].

Significance of the study

Recent studies have revealed a downward trend in rice and wheat yields [8]. Between 2001 and 2019, the growth rates of both rice and wheat production decreased [9]. Pests are destroying a significant number of grains as well. Therefore, food security is an essential issue in Nepal. Most Himalayan regions, such as Dolpa, Humla, Mugu, and Jumla face food shortages yearly [10]. The study explains one of the methods to minimize the pests on post-harvested wheat grains without adding pesticides.

II. Materials and Methods

Collection of samples

The samples were collected from the four districts of Karnali province: Surkhet, Dailekh, Kalikot, and Jumla of Karnali Province, Nepal. Wheat weevil was taken for the study and injected into each sample to proceed with the experimental procedure.

Microwave for microwave heating

The research for this project was carried out in the physics and botany lab of the Graduate School of Science and Technology, Midwest University. This study performed the whole experiment to determine mortality at different temperatures using a Samsung 21 L convection microwave oven (CE76JD-B/ XTL, black). The microwave oven generated heat at 60°C, 70°C, 80°C, 90°C and 100°C by adjusting different power.

Determination of mortality

Each sample weighed 50 grams, and then 20 adult wheat weevils were inserted into each sample. There were 50 samples of grain for each district which were injected as 20 insects per sample and then put into the conveyor of the microwave oven. The heating was done at five different temperatures i.e., 60°C, 70°C, 80°C, 90°C and 100°C. Two separate times of exposure were taken as 30 seconds and 1 minute. When the heating was done for the prescribed exposure times, each sample was taken out from the oven, and then samples were spread on a sheet of paper. The numbers of living and dead insects were counted. The insects were considered dead if they failed to respond to gentle rubbing with a small brush. The sample cooled, and the insects were rechecked for mortality after 15 min. The experiment was repeated to see if insects went missing, and the final count was not the same as the initial count. After cooling, the seeds were put on the germination.

Determination of germination

The different samples, after heating, are subjected to germination. Germination was performed for three wheat categories: Lab (control), 60°C and 100°C for one minute exposure time. The normal wheat sample means non-heated wheat; the remaining two are heated at the mentioned temperatures. For the germination, filter paper of 9 cm diameter was placed on the petri- dish with about 5.5 ml of distilled water as per the requirement, and 14 seeds on each dish were kept. The heated samples were then left for 3 days for germination at 25°C and it was considered as a control and the same sample was germinated at 290C in the incubator. Finally, the germinated seeds were counted and expressed in percentage.

Nutrition analysis

Wheat contains 78.10% carbohydrate, 14.70% protein, 2.10% fat, and 2.10% minerals, as well as a considerable number of vitamins (thiamine and B vitamins) and minerals (zinc, iron) [11, 12]. So, the nutrition level of wheat was checked before and after heating the samples in a microwave oven. Protein was tested using the protein analyzer method using the Bovine serum albumin (BSA), copper sulfate, and potassium iodide in the laboratory. Similarly, the sugar test was done using the Sodium potassium tartrate, DNS reagent, and glucose. The fat or lipid of the sample was extracted by soxhlet apparatus by using the solvent diethyl ether. To determine the fat content, 20 grams of wheat sample was ground on the mixer grinder of the Trumix model and then put on the soxhlet apparatus. After 3 hours of heating on the boiling point of the solvent. Then the fat content was determined by finding the differences in the initial and final weight of the round bottom flask after disassembling the apparatus. The weight of the resulting fat was expressed as the percentage of the total weight of the ground sample.

Statistical Analysis

After collecting the data in this experiment, the different statistical tests were done using the LibreOffice calculator [13]. After confirming the data's normality, variance analysis (ANOVA) was used to check the significance of differences between the mortality of insects of different samples and temperatures for the exposure times of 30 seconds and 1 minute. Furthermore, similar statistical approaches were also made for the samples' germination and nutrition level analysis.

III. Results and Discussion

Mortality of insects at different temperatures

The mortality rates of insects in different temperatures for the exposure time of 30 seconds and 1 minute were determined. Firstly, at a temperature of 60°C, the mortality rate is 0%. When the temperatures were increased in the microwave oven, the mortality rates gradually rose to 37%, 55%, 72%, and 95% at temperatures 70°C, 80°C, 90°C, and 100°C, respectively, on average for the exposure time of 1 minute. However, for the exposure time of 30 seconds, the mortality rates were relatively low, which were 5%, 12%, 27%, and 45%, respectively.

In the Fig. 1(a), J_{60}, J_{70}, J_{80}, J_{90}, and J_{100} indicate the mortality of wheat sample of Jumla heated for 1 minute at the temperature of 60°C, 70°**C**, 80°C, 90°C, and 100°C, respectively whereas j_{60}, j_{70}, j_{80}, j_{90}, and j_{100} indicate the mortality of the samples heated for 30 seconds at the temperature level of 60°C, 70°C, 80°C, 90°C, and 100°C respectively. According to the Fig. 1(a), the sample of Jumla holds about 95% mortality in the 1-minute time of exposure in the microwave oven. It manifests the gradual increment of the mortality rate of insects with the increment of temperature and exposure time. The result of the ANOVA test showed that the mortality rate of insects varied significantly with the temperatures ($p = 1.80 \times 10^{-72} < 0.05$).

Germination of seeds at a different temperatures

The germination test in the laboratory was conducted for different heating samples. It showed that the germination percentage of the heated sample for 1 minute exposure time at 60°C is 65.54%, 62.13%, 65.60% and 46.32% for the sample of Jumla, Surkhet, Dailekh and Kalikot respectively. In contrast, at 100°C, the germination decreased to 12.30%, 8.5%, 11.20% and 9.27%. However, at 29°C, the germinations of the wheat samples were increased to 75.66%, 63.29%, 74% and 73.23% respectively for Jumla, Surkhet, Dailekh, Kalikot.

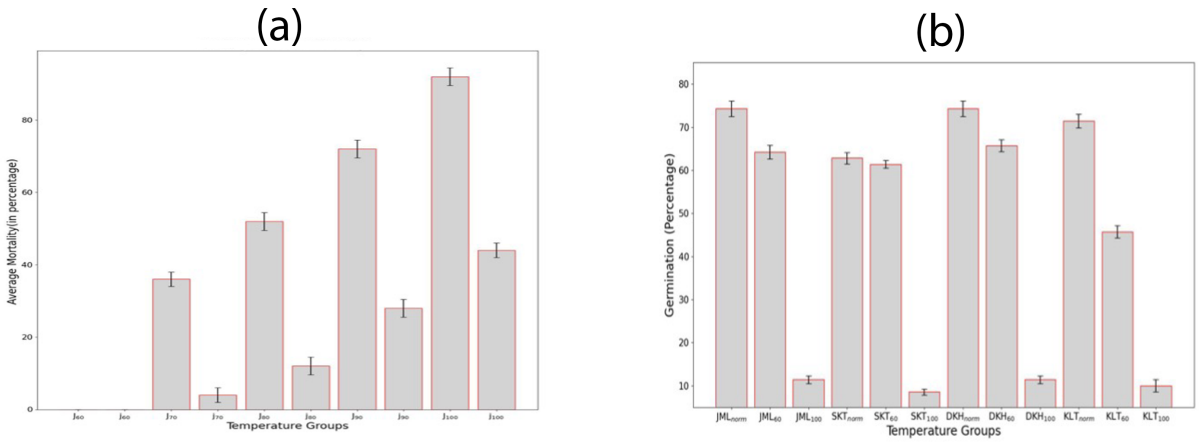

Figure 1. Error bar diagrams of (a) Mortality with temperature and (b) Germination percentage of seeds with temperature.

In the Fig. 1(b), JML_{norm}, SKT_{norm}, DKH_{norm}, and KLT_{norm} represents the germination of the sample seeds at normal temperature, JML_{60}, SKT_{60}, DKH_{60}, and KLT_{60} at 60°C and JML_{100}, SKT_{100}, DKH_{100}, and KLT_{100} at 100°C temperatures for Jumla, Surkhet, Dailekh and Kalikot respectively. The error bar diagram indicates that the germination of seeds gradually decreases with the increase in temperature. The ANOVA test of the germination data showed that germination was significant to the temperature ($p = 3.5654 \times 10^{-6} < 0.05$).

Nutrition analysis

The nutrition levels of wheat in four different districts were analyzed. For the analysis, the samples were taken as a control sample at 60°C and 100°C. The test result of the protein and lipid or fat with standard error is shown in Table 1.

Table 1. Nutrition level with standard error in wheat.

District	At lab temperature (control)		At 60°C		At 100°C	
	Protein (%)	Fat (%)	Protein (%)	Fat (%)	Protein (%)	Fat (%)
Jumla	13.02+0.19352	2.7+0.1315	13.00+0.18668	2.5+0.14303	12.92+0.125	2.6+0.10801
Surkhet	13.01+0.1498	3.1+0.06917	13.01+0.1394	2.9+0.0625	12.98+0.08182	2.9+0.04667
Dailekh	13.8+0.38704	2.6+0.263	13.75+0.37336	2.6+0.25	13.52+0.28605	2.5+0.21602
Kalikot	13.05+0.1498	2.5+0.06917	13.00+0.1394	2.3+0.0625	12.95+0.08182	2.4+0.04667

The analysis of variance between the control sample and the treated sample was performed. The ANOVA single-factor test concluded that temperatures were insignificant to the protein level of wheat ($p = 0.86808 > 0.05$). The ANOVA test of the sample for fat revealed that the variation in temperatures did not affect the fat level of the wheat sample ($p = 0.66044 > 0.05$). A similar result was obtained for the sugar test of the wheat sample. Thus, the applied temperatures of the samples do not affect the nutritional levels of wheat.

IV. Conclusions

This research concluded that mortality and germination are highly affected by the temperatures and exposure times. However, nutrition levels are quite unaffected by the applied temperatures. Although temperature somehow affects germination, grains can be treated with microwave heating for making pest free. This might be an effective tool for storing harvested grains organically.

V. Authors' Contribution Statement

Hasta Bahadur Pariyar did project design, experiment, write-up, and editing., The experiment was guided by Savita Dhungana., while Asst. Prof. Dharma Raj Paudel did supervision.

VI. Acknowledgements

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