Research Article

Management of *Tribolium castaneum* (Herbst) and *Rhyzopertha dominica* (Fabricius) by using Microwave Oven

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Abstract | Wheat, *Triticum aestivum* L., is one of most important staple food crop of Pakistan. Its grains have rich sources of proteins, fibers and minerals. This cereal crop has maximum proportion in daily basic diet of human in Pakistan. Disinfestation of wheat grains by using microwaves can be safe option than chemical control. Therefore, in this study a digital microwave oven of 50 Hz is used to determine the mortality of *Tribolium castaneum* (Herbst) and *Rhyzopertha dominica* (Fabricius) adults. Grain samples of 20 g in each petri dish were infested with both adults and exposed to microwaves for 0, 10, 20, 30 and 40 sec. For germination determination 25 seeds from each treatment were selected. Results indicates that increase in exposure time also increase the mortality but it reduces the germination capability of the grains. 20 sec exposure time of microwave oven is enough to cause maximum mortality without disturbing the germination quality of the grains.

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1. Introduction

Wheat (*Triticum aestivum*) belongs to Gramineae family is the most well known staple cereal crop of the world. It is also the staple food of Pakistan. Investigations exhibit that 72% of Pakistan daily caloric diet is accomplished through wheat flour (FAS, 2019). According to Pakistan grain and feed annual report, the harvested wheat crop forecast was 26.3 million metric tons during year of 2018-2019 (Raza, 2018). It has very important nutritional value (Hailu, 2018). Because it has essential dietary fibers, protein, minerals and protein sources which are excellent for health building (Kumar *et al*., 2011). Some essential traces of minerals like magnesium and selenium that are essential for better health are present in it (Topping, 2007). The embryo of wheat seeds is rich in B-vitamins and fats (Adams *et al*., 2002). These pests can affect by various influential factors during storage and transportation. Among them insect- pests are very important biotic agents that cause serious infestation. They reduce both quality and quantity of the grains by prevailing their population (Singh *et al*., 2009).

Among variety of pests the two most damaging stored grain insect pests like red flour beetle, *T. castaneum* Herbst (Coleoptera: Tenebrionidae) and lesser grain borer, *R. dominica* (Coleotpera: Bostrichidae) cause considerable economic loss to stored cereal grains and their by-products every year (Chen *et al*., 2015). *T. castaneum* is known as cosmopolitan insect- pest of wheat and its various by-products. It causes change in color, odour and also pollute the wheat flour with cast skins and excreta (Bosly and Kawanna, 2014).

These beetles cause weight loss of sound grains by feeding on them over a certain period of time (Ali *et al*., 2009). Being serious pests of stored grains they attack numerous products of wheat such as cereals, flour, spices, nuts, beans, meal and seeds etc. (Weston and Rattlingourd, 2000). The *R. dominica* infestation cause weight deterioration, reduction in nutrient contents and essential amino acids. These results are in reduction in germination ability (Arthur *et al*., 2012).

T. castaneum and *R. dominica* management is a great challenge particularly without using of pesticides because they have bad impacts on environment. The control of most damaging pests in grain storage houses is done through different fumigants like methyl bromide and phosphine (Zettler and Arthur, 2000). But they are not good for environment and causing ozone layer reduction (Yagi *et al*., 1993). Their uses are completely bane and only considered under Montreal protocol (UNEP, 2006), because not safe for human health.

So the focus of research is on environmentally safe alternatives to manage these beetles in ecofriendly way. For controlling of stored grains insect-pests there are many safe, effective and simple methods are available without utilizing chemical insecticides specially. Among various eco-friendly methods microwaving a most useful method for the managing of insects in stored grains commodities without using insecticides (Wang *et al*., 2003; Vadivambal *et al*., 2010). Stored wheat grains and its by-products disinfestation by using microwave has been well studied against stored grain insects (Halverson *et al*., 2003; Vadivambal *et al*., 2007; Das *et al*., 2013; Agha *et al*., 2017).

Our study is focusing on the judicious use of microwaves to disinfest the wheat against the adult stages of *T. castaneum* and *R. dominica.*From this we can control its population to flare up and from economic damage. Microwave treatment effects on germination capability of wheat seeds is also determined.

2. Materials and Methods

2.1 Insect rearing

The study was conducted at Ecology lab of MNS-University of Agriculture, Multan. Cultures of both *T. castaneum* and *R. dominica* were reared on whole and broken wheat grains along with flour. The insects along with their diet kept in plastic jar of 2 kg. The jar was covered with a fine mesh allow proper ventilation and stop escaping of insects. The jars were placed in incubator at temperature 30±2°C and relative humidity 60-65% for their maximum development.

2.2 Microwave oven exposure

In experiment a digital microwave oven (Model: HMN-45110EGB) of Haier electronics company having 50Hz frequency with 1100-watt power was used. Following exposure time like 0, 10, 20, 30 and 40 seconds was used. On control treatment there were no application of microwave radiation applied and output was zero.

2.3 Mortality determination

Fifteen grams of healthy grains are placed in plastic petri dish. Five adults of *T. castaneum* and *R. dominica* were transfer to petri dishes for making replications. For each treatment three replications were used. These replications treated in oven according to different time as described in previous section. Data of the treatments were taken after 30 minutes and 24 hours. The dead stage of insects was also checked by probing with small fine camel hair brush and needle. They showed no response.

2.4 Determination of germination

The wheat seeds after treatment with microwave radiations are utilized for germination evaluation. In this experiment, counted 25 seeds were placed in each petri dishes having diameter of 9 cm. The bottom and upper part of petri dishes were covered with whatmann no. 3 filter paper to retain maximum moisture. Petri dishes were kept at 25°C and data were recorded after 7 days.

2.5 Statistical analysis

Data are recorded and analyzed by using Statistix software (8.1). The significance between mortality and germination at different exposure times was done by using Analysis of variance (ANOVA). Grouping and comparison of means were evaluated by using Tukey test.

3. Results and Discussion

3.1 Mortality of T. castaneum

The laboratory conducted experiment showed that the mortality of *T. castaneum* and *R. dominica* are

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expressively affected by the radiations of microwave oven (Table 1). The results found to be highly significant at the exposures of 20, 30 and 40 sec. after 30 min of data observing (f =27.94, df= 4, P =0.000) as well as after 24 hours (f=114.50, df= 4, P=0.000). Under similar conditions the control mortality percentages were zero. Results depicts that mortality reached 100% on exposure of 30 and 40 sec. But very few mortalities happened in exposure of 10 sec. *i.e.* 26% and 33% mortality after 30min and 24 hours respectively.

3.2 Mortality of R. dominica

No mortality of *R. dominica* was recorded in control. Highest mortality was found (f =342, df= 4, P =0.000) during data recording after 30 min at the exposures of 20, 30 and 40 and same results observed (f =139.43, df= 4, P =0.000) after 24 hours. On the other hand, only 10 sec. exposure caused 30% and 37% mortalities on aforementioned time.

Table 1: Mortality rate of *T. castaneum* and *R. dominica* in relation with exposure time.

	Exposure time (Sec)	Mortality determination	
		30 min	24 hours
		Mean±SE	Mean±SE
T. castaneum			
	10	26.667b±6.667	33.333b±6.666
	20	66.667a±17.638	86.667a±6.666
	30	100a±00.00	100a±00.00
	40	100a±00.00	100a±00.00
	0	00.00b±00.00	00.00c±00.00
R. dominica			
	10	30b±5.7735	36.667b±8.819
	20	100a±00.00	100a±00.00
	30	100a±00.00	100a±00.00
	40	100a±00.00	100a±00.00
	0	00.00b±00.00	00.00c±00.00

3.3 Germination results

Germination ability of wheat grains is main concerned after treated with microwave radiations. The values show that *T. castaneum* treated wheat grain of 0, 10 and 20 sec exposed show higher germination percentage (f=113.83, df= 4, P=0.000) as shown in Figure 1. The *R. dominica* treated grains also show maximum germination percentage (f =46.43, df = 4, P =0.001) after 7th day at 0, 10 and 20 sec exposed grains (Figure 2). The germination% decreases when exposure time increased after exposure of 30 and 40 sec.

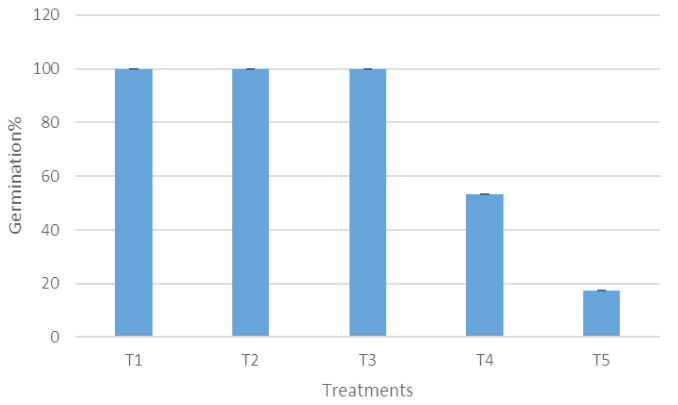

Figure 1: Germination % in *T. castaneum* treated grains.

Note: T1: Exposure of 10 sec.; T2: Exposure of 20 sec.; T3: Exposure of 30 sec.; T4: Exposure of 40 sec.; T5: Control.

Figure 1 show that *T. castaneum* treated 10 and 20 sec exposed grain show100% germination occurred as shown in Figure 1. But the of 30 and 40 sec exposed were decreased by the increasing in time exposure of microwave radiations.

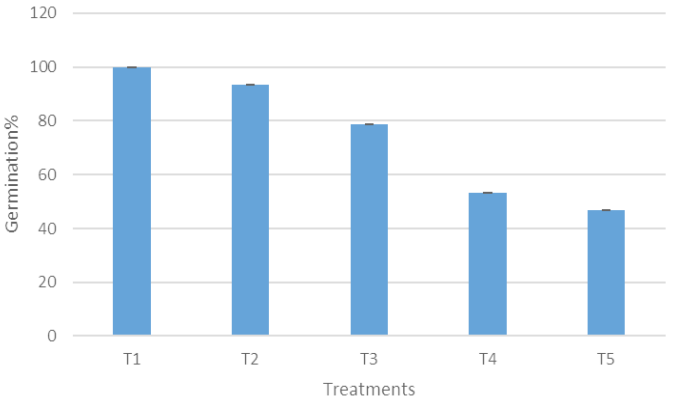

Figure 2: Germination % in *R. dominica* treated grains.

Note: T1: Exposure of 10 sec.; T2: Exposure of 20 sec.; T3: Exposure of 30 sec.; T4: Exposure of 40 sec.; T5: Control.

The *R. dominica* treated 10 and 20 sec exposed grains gives nearly 95% and 90% germination as shown in Figure 2. But germination % decreases when exposure time increased.

Current researches have showed that microwave treatment is very suitable method to replace other previous techniques. Safe environment, controlled heating and minimum energy utilization are some important characteristics of this technique. Yadav *et al.* (2014) reported that the safe option for the killing of insects-pests in stored grains without chemical methods is microwave applications. Because it cannot leave any unwanted residues and very suitable and safe strategy

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for the proper infestation. Microwave disinfestations competitive method than fumigation and also give no side effects like environmental pollution.

Our studies confirm that the increase in time exposure of microwave oven radiations directly increase the mortalities of *T. castaneum* and *R. dominica* adult stages. Similar result found by Agha *et al*. (2017) that mortality increases with increase in exposure time. They observed that high mortality 90% occurred at 840 watt output power when exposure time was 50 sec. against Khapra and Red flour beetles. In our experiment mortality of the insects is greatly influenced by various exposure times. The *T. castaneum* adultsat 20 sec. exposure show maximum mortality and complete mortalities happened when exposure time 30 and 40 sec. But El-Naggar *et al*. (2011) concluded that the mortality of *T. confusum* all stages were occurred at 50 sec exposures to microwave radiation at 50°C. Same in situation of *R. dominica* adults exposure of 20 sec exhibit 100% mortality. El-Naggar *et al*. (2011) have been confirmed that 50 sec exposure of microwave radiations at 50°Ccaused mortalities of all stages *R. dominica*.

Our research also acknowledges that the high exposures times 30, 40 sec decreased the germination capability in case of *T. castaneum* and *R. dominica* treated grains. In contrast to Abu-Elsaoud (2015) in Egypt reported that wheat cultivar Sids-1 requires 240 seconds exposure of microwave radiations at 2.45 GHz to show maximum germination. The increase or decrease in the time of microwave radiations exposures show great effects on the germination percentage of the wheat grains. Therefore, the limited and authentic exposures of microwave radiation frequencies should be applied in disinfestation of wheat grains to save their nutritional qualities. The increase and decrease in exposure time is directly dependent on mortality and germination of the wheat grains.

Conclusions and Recommendations

The 20 sec exposure of microwave oven can be used to disinfest these *T. castaneum* and *R. dominica* without disturbing their germination potential. Better estimate can be created if 20 sec exposure time can kill adult stage of these pestiferous insects without disturbing the germination potential of the wheat seeds or grains. Then the larvae, pupae or eggs stage how much effected by this exposure time. This research too much helpful for the raw products of wheat like flour etc. also if they are infested with these pests by using microwave exposure of 20sec the eradication can be easily done without disturbing their qualities. This disinfesting approach consume less time and cannot influence the end use quality of the wheat products.

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Novelty Statement

The exposure of wheat grains for 20 seconds to Microwave oven radiations is enough for disinfestation of grains from *Tribolium castaneum* and *Rhyzopertha dominica*, and does not affect the germination of the seeds.

Author's Contribution

MN, MH and MS conducted the trials. HG, SHMB reviewed the manuscript, and UN-U designed the research.

Conflict of interest

The authors have declared no conflict of interest.

References

Abu-Elsaoud, A.M., 2015. Effect microwave electromagnetic radiofrequency on germination and seedling growth consequences of six wheat *Triticumaestivum* cultivar. *Advances in Environmental Biology*, 9(24): 270-281.

Adams, M.L., Lombi, E., Zhao, F.J. and McGrath, S.P., 2002. Evidence of low selenium concentrations in UK bread-making wheat grain. *Journal of Sciences Food Agriculture*, 82: 1160–1165. https://doi.org/10.1002/jsfa.1167

Agha, W.NA., Amin, A.H., Khidr, S.K. and Ismail, Y.A., 2017. Entomocidal activity of microwave energy and some aqueous plant extracts against *Triboliumcastaneum* Herbst and *Trogodermagranarium* Everts. *In AIP Conference Proceedings*, 1888(1): 020005. https://doi.org/10.1063/1.5004282

Arthur, F.H., Ondier, G.O. and Siebenmorgen,

T.J., 2012. Impact of *Rhyzopertha dominica* (F.) on quality parameters of milled rice. *Journal of Stored Product Research*., 48: 137-142. https://doi.org/10.1016/j.jspr.2011.10.010

Bosly, H.A.Q. and Kawanna, M.A., 2014. Fungi species and red flour beetle in stored wheat flour under Jazan region conditions. *Toxicology and Industrial Health*, 30: 304-310. https://doi.org/10.1177/0748233712457449

Chen, Z., Schlipalius, D., Opit, G., Subramanyam, B and Phillips, T.W., 2015. Diagnostic molecular markers for phosphine resistance in US populations of *Tribolium castaneum* and *Rhyzopertha dominica*. *PLoS One*, 10(3). https://doi.org/10.1371/journal.pone.0121343

Das, I., Kumar, G. and Shah, N.G., 2013. Microwave heating as an alternative quarantine method for disinfestation of stored food grains. *International Journal of Food Sciences*, 926468. https://doi.org/10.1155/2013/926468

El-Naggar, S.M. and Mikhaiel, A.A., 2011. Disinfestation of stored wheat grain and flour using gamma rays and microwave heating. *J. Stored Prod. Res*., 47(3): 191-196. https://doi.org/10.1016/j.jspr.2010.11.004

FAS, Islamabad, 2019. Pakistan: Grain, G and Feed Annual. USDA Foreign Agricultural Service: Washington, DC, USA.

Hailu-Kassegn, H., 2018. Determination of proximate composition and bioactive compounds of the Abyssinian purple wheat. *Cogent Food and Agriculture*, 4(1): 1421415. https://doi.org/10.1080/23311932.2017.1421415

Halverson, W.R., Bigelow, T.S. and Halverson, S.L., 2003. Design of high power microwave applicator for the control of insects in stored products. *American Society of Agricultural Engineers, St. Joseph, Michigan*. Paper No. 036156.

Kumar, P., Yadava, R.K., Gollen, B., Kumar, S.R., Verma, K. and Yadav, S., 2011. Nutritional contents and medicinal properties of wheat: A review. *Life Sciencesand Medical Research*, 22: 1-10.

Raza, A., 2018. Pakistan: Grain and Feed Annual. USDA Foreign Agricultural Service: Washington, DC, USA.

Singh, C., Jayas, D., Paliwal, J. and White, N., 2009. Detection of insect-damaged wheat kernels using near-infrared hyperspectral imaging. *Journal of Stored Products Research*, 45: 151–158. https://doi.org/10.1016/j.jspr.2008.12.002

Topping, D., 2007. Cereal complex carbohydrates and their contribution to human health. *Journal of Cereal Sciences*, 46: 220–229. https://doi.org/10.1016/j.jcs.2007.06.004

UNEP, 2006. Handbook for the Montreal Protocol on Substances that Deplete the Ozone Layer; UNEP/Earthprint: Nairobi, Kenya, pp. 10–11.

Vadivambal, R., Jayas, D.S. and White, N.D.G., 2007. Wheat disinfestation using microwave energy. *Journal of Stored Products Research*, 43: 508–514. https://doi.org/10.1016/j.jspr.2007.01.007

Vadivambal, R., Jayas, D.S. and White, N.D.G., 2010. Determination of mortality of different life stages of *Triboliumcastaneum* (Coleoptera: Tenebrionidae) in stored barley using microwaves. *Journal of Economic Entomology*, 101(3): 1011-1021. https://doi.org/10.1093/jee/101.3.1011

Wang, S., Tang, J., Cavalieri, R.P. and Davis, D.C., 2003. Differential heating of insects in dried nuts and fruits associated with radio frequency and microwave treatments. *Transactions of the American Society of Agricultural and Biological Engineers*, 46: 1175–1182. https://doi.org/10.13031/2013.13941

Weston, P.A. and Rattlingourd, P.L., 2000. Progeny production by *Triboliumcastaneum* (Coleoptera: Tenebrionidae) and *Oryzaephilussurinamensis* (Coleoptera: Silvanidae) on maize previously infested by *Sitotrogacerealla* (Lepidoptera: Gelechiidae). *Journal of Economic Entomology*, 93: 533-536. https://doi.org/10.1603/0022-0493-93.2.533

Yadav, D.N., Anand, T., Sharma, M. and Gupta, R.K., 2014. Microwave technology for disinfestation of cereals and pulses (2014) An overview. *Journal of Food Sciences and Technology*, 51(12): 3568-3576. https://doi.org/10.1007/s13197-012-0912-8

Yagi, K., Williams, J., Wang, N. and Cicerone, R.J., 1993. Agricultural soil fumigation as a source of atmospheric methyl bromide. *Proceeding of the National Academy of Sciences*, 90(18): 8420–8423. https://doi.org/10.1073/pnas.90.18.8420

Zettler, J.L. and Arthur, F.H., 2000. Chemical control of stored product insects with fumigants and residual treatments. *Crop Protection*, 19: 577–582. https://doi.org/10.1016/S0261-2194(00)00075-2