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Effect of Microwave Aided Disinfestation of *Callosobruchus Maculatus* on Green Gram Quality

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Abstract

Pulses constitute an important part of the daily diet of vegetarian population as a major source of protein. It is estimated that insects cause the most damage to the pulse grains during storage and pulse bruchids are the major storage pests. The stored pulses are usually fumigated to wade away the insect infestation. The residual effect of these chemicals on public health and growing resistance of these insects to chemicals have encouraged use of chemical free disinfestations measures. Microwave radiation provides safe and hygienic mode of disinfestation. Dielectric heating of the biomaterials (grain and insects), depends largely on the moisture content in the product. Therefore, differential heating during microwave exposure seems to be a better option for food grain disinfestation. The most heat tolerant stage of pulse bruchids, adult (*Callosobruchus maculatus*), adults were subjected to microwave heating in a domestic microwave (2450 MHz, 900W) oven for different grain bed thickness (single layer to 2.0 cm). It was observed that as the grain bed depth increased the death time for the adults increased. Hundred per cent mortality was achieved for adults in green gram (mc=8%, wb) at 50, 60, 90, 110, and 120 s for single layer,0.5, 1, 1.5, and 2cm with corresponding microwave power densities of 13, 5, 3, 1.75 and 1.5 W/g, respectively. Quality of the green gram in terms of germination ability, cooking quality, loss of moisture, colour values, were evaluated. The germination percentage and cooking time varied from 58 to 100 % and 27 to 31 minutes, respectively. The textural hardness decreased with progress in cooking time. Total moisture loss and Hunter Lab scale colour change (ΔE) values varied from 0.054 to 0.622 % and 1.23 to

0.34, respectively for different treated samples with respect to control sample.

Keywords: pulse bruchid, green gram, microwave energy, disinfestations, colour, cooking quality

1.0 Introduction

Pulses are the major vegetarian protein source, often termed as "poor men's meat". It constitutes an important part of the daily diet of largely vegetarian population of India (Mangaraj et al., 2013). India imports pulses to meet the domestic demand, despite increased production of pulses for the past few years (FAO 2012). The production when is not accompanied with safe storage practices often culminate in to huge losses that may arise from insect infestation, microbial growth, damage by rodents, birds etc. It is estimated that insects cause the most damage to the grains and the devastated damage can trail from the farm to the storage. Insect infestation can occur from the field, the conveyors and storage bins. In general practice, the stored pulses are usually fumigated eliminate insect infestation. However, due to residual effect of these chemicals, which has detrimental effect on flora and fauna health, the recent trends is now to develop new chemical free technologies for safe storage of grains. Moreover, insects are developing resistance to the most commonly used chemicals, which is due to the indiscriminate use of pesticide doses.

Microwave energy has been used in various food processing operations such as drying, blanching, sterilization, pasteurization, extraction of bioactive compounds to name a few (Mohapatra and Mishra, 2011). Recently, application of microwave energy for disinfestations measures has gathered momentum (Vadivambal and Jayas, 2007; Yadav et al., 2012). Microwave radiation through dielectric heating provides safe and hygienic mode of disinfestation. Dielectric heating in the biomaterials (grain and insects), depend largely on the moisture content. Therefore, differential heating during microwave exposure seems to be a better option for food grain disinfestations including pulses (Halverson et al., 1996; Johnson et al., 2010, Wang et al., 2008, 2010). Though microwave heating has been applied commercially in various food processing operations, its application as a disinfestations measure is yet to be commercialized due to lack of substantial information and reports of detrimental effect of microwave on product quality (Vadivambal and Jayas, 2007). Therefore, this research work was carried out to disinfest green gram from pulse bruchids using microwave energy and to study the effect of microwave energy on the quality.

2.0 Materials and Methods

2.1. Mortality testing

Greengram samples were purchased from the local market. The samples were washed and dried before experimentation. The initial moisture content of the samples was determined using air oven method. Live adult insects *(Callosobruchus maculatus)* (10

nos) reared on green samples were introduced into each samples. The samples were then exposed to microwave heating in a domestic microwave oven (Samsung, 2450 MHz, 900W). Samples were contained in a 20.5×14 cm microwavable glass tray. Different grain bed depths (single grain layer, 0.5, 1.0, 1.5 and 2 cm) were maintained. Samples were taken out at 10 s intervals after 30 s microwave exposure and the mortality was observed. Mortality time was noted when 100% mortality of the insects were achieved. A representative sample without any treatment was referred as control.

2.2 Moisture loss estimation

After the treatments, the moisture content of the samples was measured by standard air oven method, by keeping 5 g of representative sample in a laboratory hot air oven at 105°C for 24 h. the difference in the weight was represented as moisture loss from the samples. Average of duplicate sample was considered for the analysis.

2.3 Germination percentage:

Germination ability was measured by soaking the samples overnight at 25°C and keeping them in the incubator for 24 h on a moist tissue paper. The germination percentage was taken by considering 100 grains in triplicate.

2.4 Protein content estimation

The grains were ground to fine powder by mortar and pestle. The powdered samples were sieved through 100 mesh size and about 250 mg sample was taken from each treatment for the estimation of protein. Protein content of the samples was determined using Kjeldahl method as total nitrogen by multiplying a factor of 6.25. The samples were analysed in duplicate.

2.5 Colour values determination

The hunter Lab colour values were estimated using CIE colour Lab (Lab scan). The instrument was calibrated against white and black tiles. The parameter a takes positive values for reddish colours and negative values for the greenish ones, whereas b takes positive values for yellowish colours and negative values for the bluish ones. L is an approximate measurement of luminosity, which is the property according to which each colour can be considered as equivalent to a member of the grey scale, between black and white. The change in colour was calculated with respect to the control sample suing the following expression:

$$\Delta E = \sqrt{(\Delta a^{*2} + \Delta b^{*2} + \Delta L^{*2})} \quad ..(1)$$

Where, Δa, Δb, ΔL, were difference between control and treated samples. Each measurement was performed thrice and the average values were considered for calculation.

2.6 Cooking quality estimation:

For cooking time determination, 2 g of samples were tied in muslin cloths and immersed in boiling water. From time to time samples were taken out and compressed between two glass slides till no core was visible.

2.7 Textural attributes of the cooked green gram sample:
The textural hardness during cooking was measured using a texture analyser (TA xi, Stable Microsystems, UK). The study was conducted by using 50 kg load cell and with a 100mm compression plate for compressing single grain to 90% strain. The pretest, test and post test speeds were kept at 0.5 mm/s. The grain were cooked in excess water system, tied up in muslin clothes and at every 5 minutes the samples were taken out for textural study. The measurement was completed within 1 hour of the cooking. The compressive hardness of 20 grains from each sample and the average values were noted.

2.8. Statistical analysis:
Analysis of variance was conducted to find out if the treatments were significantly different by using Microsoft excel.

3.0 Results and Discussions

3.1 Effect of grain bed depth on insect mortality
It was observed that as the grain bed depth increased the death time for the adults increased. Within 30 seconds of exposure no mortality was observed for all the samples. Hundred per cent mortality was achieved for adults in green gram (mc=8%, wb) at 50, 60, 90, 110, and 120s for single layer, 0.5, 1, 1.5, and 2cm with corresponding microwave power densities of 13, 5, 3, 1.75 and 1.5 W/g, respectively (Table 1). Since microwave heat generation depends on the product load, moisture content and composition of the biomaterials, as the load increased, corresponding volumetric heat generation in the insects as well as grains would be less, hence at lower grain load mortality was higher. As the load increased, more microwave energy was required to generate sufficient heat to eliminate the insects. This information will be useful in commercial installations where huge amount of grains are handled. This also gives an insight that microwaves can penetrate and can eliminate the insects even if they not on the surface of the grains.

3.2 Effect of microwave exposure on moisture content
The initial moisture content of the samples was 8% (wb). On microwave exposure from 50 s to 120 s for different microwave power densities, the moisture loss was hardly 0.5% (Table 1). Due to dielectric heating, polar molecules like water vibrate and collide which results in heat generation that helps the water molecules to evaporate. Similar observations were observed by Shayesteh and Barthakur (1996) and Jiao et al. (2012), while disinfesting pulses in microwave.

3.3 Effect on germination ability of green gram
The germination ability of the samples decreased from 100 to 58% for different samples (table 1). Higher was the residence time lesser was the germination percentage. It was also affected by the microwave power density. Similar results were observed by Singh et al. (2012). Since the germination ability is negatively affected by the microwave exposure, the grains may be used for food purpose only.

Table 1: mortality, moisture loss, germination ability and protein content of the microwave treated samples

Samples	Residence time, s	MW Power density, W/g	moisture loss, %	Germination, %	Protein, %)db)
Control	0	-		100	23.67
Single	50	12.8	0.453	71	23.25
0.5 cm	60	5.0	0.299	69	23.14
1.0 cm	90	3.0	0.053	53	21.47
1.5 cm	110	1.75	0.622	48	22.21
2.0 cm	120	1.5	0.366	49	23.26

3.4 Effect on protein content of green gram

The protein content of the samples varied between 21-23% (Table 1). The difference between the control and treated samples was not significant, however. Though there was some variation in the protein content, the change was not large enough to mar protein content of the samples. Moreover, the moisture content of the sample was low (8%, wb), so much volumetric heat was not generated to affect the protein quality of the grain. The treated samples were at par with the control samples. Though in some studies protein content was found to be affected by microwave exposure (Purohit et al., 2013).

3.5 Effect on colour values

It was observed that the L, a, and b values were different for the control samples (Table 2). The major factor to be considered is the 'a' value. It was observed that the negative a values decreased for the treatments. The total change in colour as represented by ΔE also varied with the treatments. More was the residence time, higher was change in colour. The grains in single layer though exposed for less time have higher colour change values as compared to grains in 0.5 cm depth as the power density in the later case was lower and it did not affect the colour of the grains by burning them. Some amount of browning was noticed in the single layered samples as much heat was evolved. The values were not statistically significant at at p 0.05.

Table 2: Colour values and cooking time of green gram samples

Samples	L	A	b	ΔE	Cooking time, min
Control	39.69	-0.81	27.95	-	31
Single layer	39.4	-0.26	27.47	0.785493	30
0.5 cm	39.7	-0.47	27.97	0.340735	27
1.0 cm	39.79	-0.63	27.14	0.835763	28
1.5 cm	38.47	-0.62	27.85	1.238749	29
2.0 cm	39.2	-0.69	27.19	0.912195	28

3.6 Effect on cooking quality

The cooking time was found to vary between 27 to 31 minutes (table 2). The treated samples had lesser cooking time as compared to the control sample. Similar results were reported by Jiao et al (2012) for lentils. Since heat is generated inside the grains during microwave heating, that might have caused fine fissures, resulting in higher diffusion in the treated samples during cooking.

3.7. Textural harness kinetics as affected by MW treatment

The effect of cooking time and microwave treatment on textural hardness is shown in figure 1.

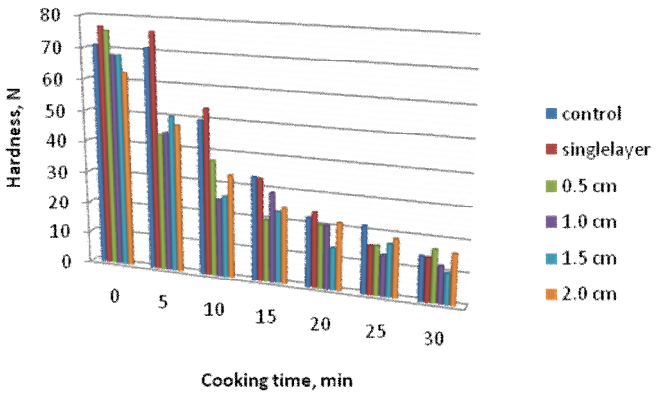

Figure 1. The textural behaviour of control and Microwave treated green gram samples with progress in cooking time

It was observed that the textural harness decreased as the cooking time progressed, which was due to the softening of the tissues through water absorption. The textural harness of the control sample was higher as compared to the treated samples for all the cooking time; the reason was explained in the previous paragraph. It was observed that hardness of the single and 0.5 cm depth samples were higher as compared to the control samples, but the textural harness tend to decrease after 15 minutes of cooking. This reason could be as many hard to cook grains were affecting the textural harness during the initial stage, as the cooking time progressed some of the grains were also found to be cooked. Initially the standard deviation values were higher; as the cooking time progressed the values decreased from 27 to 4N, 20 N to 3 N, 18 to 2 N, 28 to 2 N, 17 to 2.5N, and 17 to 3.5 N for control, grains with single layer, 0.5 cm, 1.0 cm, 1.5 cm and 2.0 cm bed depths, respectively.

4.0 Conclusions

It can be concluded that the pulse bruchids can be eliminated even if they are hiding inside the grain and are located in a depth. Microwaves can generate enough volumetric heat in the grain and the insects to attain mortality. The residence time is higher as the power density increases, so it would take more time to kill the insects if the grain sample size is more, which is of commercial significance. Moreover, the

moisture loss, protein content and cooking quality are not significantly affected by the microwave exposure. In fact, the cooking time decreased for the treated samples. Though the grains acquired harness due to microwave exposure, as the cooking time progressed all the grains would be cooked with reduced textural hardness

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