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EFFECT OF FLUIDIZED BED HEAT TREATMENT ON INSECT MORTALITY, PROXIMATE COMPOSITION AND ANTINUTRITIONAL CONTENT OF STORED GREEN GRAM (*VIGNA RADIATA*) SEEDS

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A B S T R A C T

The study describes the effect of fluidized bed heating for different temperature and time combination on insect mortality, chemical composition viz., moisture, protein, crude fiber, fat, carbohydrate and ash of a high-yielding variety of green gram (*Vigna radiata*) Malviya-12. Raw seeds also contain significant amount of anti-nutrients. Phytic acid is one such anti-nutrient which is a major storage form of phosphorous in legumes seeds. Insect for experiment cultures were taken from stored grain stocks reared for many generations in laboratory conditions 32°± 1°C, and 60 ± 5 percent relative humidity. For fluidized bed dryer, samples of weighing 500 to 1000 gram were prepared. Infested sample treated with fluidized bed for different time interval. After treating green gram (*Vigna radiata*) seeds in a fluidized bed for exposure time 40, 50 and 60 sec and different temperature 40, 60 and 80°C. Maximum insect mortality occurs for exposure time 60 sec and temperature 80°C. Seeds stored for a long time because moisture of grain removes after heat treatment. The results indicate that the fluidized bed heating reduces the moisture content, increase the insect mortality, little changes in chemical composition of green gram (*Vigna radita*) and lowered the anti-nutrient factor (phytic acid).

Keywords: Physical control, Fluidized bed heating, Pulses, *Bruchidae*, Anti-nutrient, proximate chemical composition, green gram.

INTRODUCTION

Food is a basic necessity for human existence and perhaps the most precious commodity on earth. During the last five decades, production of food has been increased significantly. But the challenge of feeding ever growing human population cannot be met with the increase of food production alone. Pulses constitute rich sources of proteins, vitamins and minerals for the predominantly vegetarian population in India. They are popularly known as "poor man's meat" and "rich man's vegetable" (Singh and Singh, 1992).

In India, pulses are the second most important crops next only to cereals, occupying an area of 23.8 million hectare, with a production of 15.2 million tons per year (Agricultural and Processed Food Products Export Development Authority 2007, accessed on 3 May 2009, http://www.apeda.com) Black gram (*Vigna mungo*) and Green gram (*Vigna radiata*) is seasonally produced but consumed throughout the year so the supply of this is to be maintained throughout the year by their proper post harvest management safe storage through the year. Among food grains, pulses are difficult to store and they suffer a great damage during the storage due to growth of insect pests and microorganisms (Akhtari *et al.,* 1993). *Callosobruchus maculatus* and *C. chinensis* are responsible for grain losses estimated at 20–60% (Arbol, 1999; Tarver *et al.,* 2007). Stored pulses are severely infested by beetles of the family *Bruchidae* (*Coleoptera*) popularly known as pulse beetles or *Bruchids*. They are very prominent in its incidence and include a number of economically important species that attack stored pulses throughout the world (Hill, 1993). Pulse beetles assume greater importance as they damage the pulses both in the field as well as during storage. Although, several species of *bruchids* are known to damage grain legumes, the members of the genus *Callosobruchus*, which show greater specificity to attack cultivated pulses, are

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particularly destructive (Jotwani *et al*., 1967). This problem is further complicated as the infestation by *Callosobruchus* is invariably carried over from field to storage (Sangappa and Balaraju, 1977). Disinfestations on stored grain and cereals by elevated temperature are carried out by using radiant heating processes such as infrared, microwave, and dielectric heating (Boulanger *et al.,* 1971; Nelson, 1972; Kirkpatric and Tilton, 1972; Waters, 1976). The major advantage of thermal treatment is non residual and rapid method of control of insect pest. Safe storage requires rapid decrease in moisture to preserve quality. Fluidized bed technology is a rapid method to decrease the moisture content and disinfest the stored grain rapidly. In a fluidized bed heating air passes vertically upward through a bed of grain at a velocity sufficient to lift and mix the individual grain kernels. (http://www.ciart.it/Biblioteca/MICROWAVE/THERMA.pdf).

In this study, we focus on the determination of moisture content, insect mortality, chemical composition and anti-nutrient content of stored green gram. Drying helps to remove the moisture from the food products without the problem of case hardening (Prabhanjan *et al.,* 1995), moisture content is the important factor for storage and controlling the insect pest of grain. Thermal treatment also improves the nutritional quality of food legume due to reduction in anti nutrient (Hania and Niely, 2006). The objective was to investigate the effect of fluidized bed treatment on controlling the stored insect pests of green gram without any adverse effect on quality of grain.

MATERIAL AND METHODS

Sample collection: Green gram (Malviya12) seed were procured from the experimental farm of Banaras Hindu University, Varanasi, India. Green gram seeds (500-1000 g) were cleaned and any foreign matter was removed manually before its use in the experiment.

The Fluidized bed heat treatment apparatus: The Fluidized bed dryer which used in this study is shown in Figure 1. Details of fluidized bed dryer are as follows: Basic Technology Pvt. Ltd. (BTPL) Model: Lab Dryer Manufactured by: Basic Technology, Kolkata India Address: Nandy Street, Calcutta- 700029 Basic capacity: 300-1500 g Temperature: Max 80°C.

In a fluidized bed, air is passed vertically upward through a bed of grain at a velocity sufficient to lift and mix the individual grain kernels. The grain kernels quickly come to the air temperature so the grain can be quickly heated cooled and passed through the system. Fluidization largely depends on solids characteristics, primarily size distribution, density, shape and surface condition. Fluidized bed consists of a column of granular solids supported on a porous bottom or distributor, the diameter of fluidizing chamber was 14.5 cm. Infested (sample used in triplicates) of green gram seeds of weight 500g was taken for experiment purpose and treated with hot air for 40 to 60 sec. Velocity of the air at the outlet (with cloth and without cloth) and inlet was 3.86, 14.14 and 5.63 m/s respectively, measured with the help of Anemometer. For minimum fluidization, superficial velocity was 1.6 m/s.

Figure 1. Fluidized bed dryer

Insect cultures: Experimental culture (*Callosobruchus sp.*) were taken from stored grain stocks of the Entomology laboratory of the Agricultural and Food Engineering Department and maintained at 32°± 1°C and 60 ± 5% relative humidity to obtain larvae and adults which were separated from rearing medium and placed in petri dishes for studies.

Samples preparation: Cleaned green gram seed samples of 3 kg each were placed in air tight plastic containers of 4 kg capacity in triplicate at room temperature. In each container, 100 pulse beetles of same size were released irrespective of sex, covered with lids and the containers stored at room temperature (32°± 1°C and 60 ± 5% relative humidity) and one thousand numbers of infested grains were sampled at monthly intervals upto 6 months. Level of infestation was determined on the basis of the number of holes present in grains. Non-infested controls for pulse were analyzed for comparison.

The insect mortality assessment: The green gram seeds sample were taken out of the fluidized bed dryer treatment chambers cooled and counted for the number of insects. Samples were also counted for total insects before each treatment. The mortality percent was calculated using (Abbott WS, 1925) formula Eq. 1.

$$\% = N_o - \frac{N}{N_o} \times 100$$

Where N_0 = Total no. of live insect's before treatment, N = Total no. of live insect's after treatment.

Chemical analysis: Proximate chemical composition (moisture content, carbohydrate, protein, crude fibre, ash and fat) of the raw and fluidized bed dryer treated samples was determined by standard (AOAC, 2003) procedures. Phytate P was extracted in 3% trichloroacetic acid and (assayed by using a spectrophotometer model of instrument is systronics UV Vis) at 480 nm as method which described by (Wheeler and Ferrel, 1971).

Statistical analysis: All data were analyzed statistically. The data were treated for analysis of variance and least significant difference (p<0.05) was used to compare the effect of different temperature with respect to the time on insect mortality, chemical composition and antinutrient (phytic acid). Duncan multiple test was analysed by software SPSS.

RESULT AND DISCUSSION

Insect mortality: Infested green gram seeds were given fluidized bed at varying temperature level for different exposure time. The insect mortality increased with increase in temperature and exposure time (Table 1). The insect mortality was highly influenced by temperature level and exposure time (p<0.05). Same result was found by Vadivambal *et al,* 2007 and Vadivambel *et al,* 2010 in stored corn and wheat respectively, as the power and exposure time increases insect mortality also increased. In 2000 Mourier and Poulsen studied on control of insects and mites in wheat grain using a high temperature/short time technique. Wright *et al,* 2002 and Beckett and Morton 2003 also reported control of insect infestation by elevated temperature in storage of grains.

Chemical analysis

Grain proximate chemical composition analysis: The proximate chemical compositions (moisture content, carbohydrate, protein, crude fibre, ash and fat) of Malviya- 12 green gram (*Vigna radiata*) in their raw and fluidized bed treated sample at different temperature and time combinations.

Table 1. Temperature and time effect on reduced (moisture content) and insect mortality.

Set temperature of fluidized bed dryer (^{0}C)	Exposure time (s)	Grain temperature (^{0}C)*	Reduced moisture content (db)(%)	Insect mortality (%)
40	40	35.1	1.4	45
	50	36.2	1.7	49
	60	38.3	2.2	52
60	40	48.5	2	80
	50	55	2.4	85
	60	58.5	2.7	100
80	40	64.6	3.08	92
	50	69	4.12	100
	60	71.3	5	100

(* grain temperature measured by digital thermometer).

The results of the proximate chemical composition of raw and treated samples show in (Table. 2). Moisture content and ash shows the significant difference at all the fluidized bed temperature level and exposure time, since as the temperature and exposure time increases moisture content reduces due to heat treatment but protein, fat, and carbohydrate shows no significance difference at the respective fluidized bed temperature level and exposure time, crude fibre shows only significant difference at higher and lower range of temperature level and time of treatment. The proximate chemical composition of green gram shows very little variation from the control (untreated) and treated sample. This is due to the level of insect infestation because insect degrade to some extent the proximate chemical composition of green gram. Similar result for above study was good agreement with the value reported by several researchers (Agugo and Onimawo, 2009; Paul, 2011; Pande, 2012) the slight differences may be due to location and variety effect.

Anti-nutrient content: Antinutriental factor i.e (phytate P) decresed linearly with increase in temperature of fludization (Figure 2). The temperature and time of fludization had significant ($P<0.05$) effect on the nutrient and phytic acid contents of green gram. The loss of phytic acid during heating may be caused by hydrolytic activity of the enzyme phytase. Heat treatment like microwave heating lowered the trypsin inhibitor which is also antinutrient factor without eliminating it completely in raw faba beans, lentils, green and mature peas (Hernandez *et al.,* 1998; Pande *et al.*, 2012).

Table 2. The proximate chemical composition of control (untreated) and fluidized bed treated green gram.

Treatment	Moisture content	Carbohydrate	Protein	Crude fiber	Ash	Fat
Control	13.39	53.97	21	6.45	3.99	1.2
Time (s)/Temp			**40^{0}C**			
40	13^h	52.3^a	22.44^{ab}	7.56^d	2.63^d	2.07^{ab}
50	12.9^e	53.38^{ab}	22.39^a	6.7^b	2.55^b	2.08^a
60	12^e	55.32^{bc}	21.29^a	6.86^c	2.52^c	2.01^{ab}
Time (s)/Temp			**60^{0}C**			
40	11^g	57.57^e	21.51^{ab}	5.52^c	2.4^c	2^{ab}
50	10.62^d	54.89^{bcd}	24.77^b	5.45^a	2.27^a	2^{ab}
60	10^c	55.4^{bcde}	24.92^a	5.23^c	2.45^c	2^{bc}
Time (s)/Temp			**80^{0}C**			
40	10.7^f	57.15^{cde}	21.55^{ab}	6^c	2.51^c	2.09^a
50	10.5^b	57.46^{cde}	21^b	6.17^b	2.61^b	2.26^{ab}
60	9.03^a	58.28^{de}	21.43^{ab}	6.03^e	2.77^e	2.46^c

Means within rows followed by the same letter are not significantly different by Duncan test ($p <0.05$).

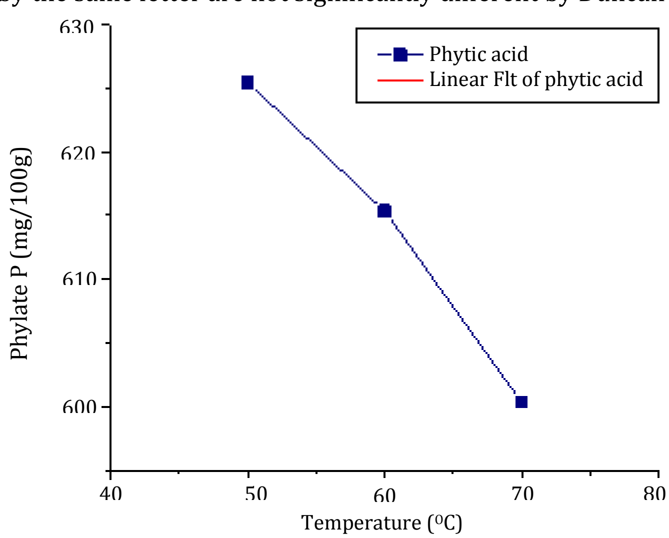

Figure 2. Destruction of phytic acid with temperature in fluidized bed heating.

CONCLUSION

The results from our study show that fluidized bed heating have a potential to kill the stored grain insects of legume i.e *Callosobruchus sp.* Reduced moisture content, hundred percent insect mortality and lower phytic acid obtained at different temperatures 40, 50, 60°C and exposure time 40, 60, 80 s exposure time without any adverse effect on quality of grain because there was no significant difference in the proximate chemical composition between control and fluidized bed treated sample.

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