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RESEARCH PAPER

Bioprospecting *Capsicum chinense* Fruit Powder Against *Callosobruchus chinensis* (Coleoptera : Bruchidae)

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ABSTRACT

The bioefficacy evaluation of *Capsicum chinense* fruit powder against *Callosobruchus chinensis* attacking green gram seeds showed a dose-dependent adult mortality (16.67 - 55.00%) at 96 hours after treatment (HAT) with a positive correlation to the exposure period. The lowest LC_{50} value of 13.04 g/100.0 g of green gram seed was recorded at 96 HAT. Admixing of *C. chinense* fruit powder recorded the lowest adult emergence (36.00%) at a dosage of 10.0 g/100.0 g seed after 23 days of treatment suggesting strong ovicidal properties, as against 91.50% adult emergence in the control.

HIGHLIGHTS

- Pulse beetle, *Callosobruchus chinensis* L. (Coleoptera : Bruchidae), is the most widely distributed insect pest causing up to 100% damage.
- The insecticidal properties of *Capsicum* sp. has successfully been demonstrated against several insect pests.
- *Capsicum chinense* fruit powder showed both insecticidala and ovicidal properties.
- The highest of 55.00% adult mortality at dosage of 10 g per 100 g seed with a LC_{50} values of 13.04 g/100 g seeds.
- *Capsicum chinense* fruit powder showed 64.0% reduction in adult emergence at dosage of 10 g per 100 g seed.

Keywords: *Capsicum chinense*, *Callosobruchus chinensis*, adult mortality, ovicidal property

Pulses are an unavoidable constituent of our daily diet, especially for vegetarians due to their rich composition of proteins (21-25%) and carbohydrates (60–65%) apart from essential minerals (iron, zinc, calcium, magnesium), vitamins and dietary fibres (Singh *et al*. 2022). Green gram (*Vigna radiata* L. Wilczek, Fam. Fabaceae) is one of the oldest pulse crops known for its adaptability to a diverse tropical and subtropical climatic condition (Malik *et al*. 2021). India produces 3.17 million tons of mung bean from a total of 5.5 million hectares at a productivity of 570 kg/ha during 2022 as compared to 721 kg/ha productivity globally (Indian Institute of Pulses Research, Kanpur, https://iipr.icar.gov.in/mungbean). Insect pests are regarded as the prime factor causing significant yield loss globally. Green gram encounters infestation of 64 different insect pest species (Nair, 1986), of these 25 species are responsible for causing about 30% yield losses at various stages of crop growth (Saini *et al*. 2023). Additionally, nearly 8.5% annual post-harvest loss of green gram (Raja and Ignacimuthu, 2000) can be seen due to the effect of abiotic factors

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(relative humidity, moisture and temperature) and biotic factors (fungi, microorganisms and insect pest attack) during storage. Amongst the insect pests attacking stored pulses, the pulse beetle, *Callosobruchus chinensis* L. (Coleoptera : Bruchidae), is the most widely distributed major insect pest causing up to 100% damage to the stored pulses including mung bean, urd bean, pea, cowpea, pigeon pea, adzuki bean, lentil, and others (Yewle *et al*. 2022). They cause damage to the stored pulses by egg laying, boring and chewing grains making them unsafe for human consumption (Varma and Anandhi, 2010). The damage of *C. chinensis* was found ranging from 5-10% in temperate regions, while 20-30% in tropical countries (Kedia *et al*. 2015).

Protection of stored pulses has been a challenge for the farming community as the application of chemical pesticides might lead to residual toxicity, increased application costs, pest resistance, harm to non-target organisms, and most importantly health hazards. Moreover, stringent regulations on the safe use of synthetic insecticides in stored food grains limit the available options for pest management in storage (Singh and Kaur, 2018). On the other hand, botanicals could serve as potential alternatives to synthetic pesticides with proven bio-toxicity against insect pests (Kalita and Hazarika, 2020; Akhter *et al*. 2023; Kayange *et al*. 2022). Botanicals were found bio-degradable with minimal residue on agricultural produce and possess secondary metabolites like terpenoids, phenolics, and nitrogenous compounds that act as antifeedant, anti-ovipositional, ovicidal, repellent, insecticidal, and insect growth regulatory agents (Al-Khayri *et al*. 2023). The king chilli, *Capsicum chinense* (Family: Solanaceae) commonly known as ghost pepper, ghost chili, *U-morok*, *red naga, naga jolokia, bhut jolokia* and *ghost jolokia* and is native to the Northeastern States of India. The genus *Capsicum* contains capsaicinoids like Capsaicin and dihydrocapsaicin, which are responsible for pungency. The insecticidal properties of *Capsicum* sp. has successfully been demonstrated against *Aphis cytisorum* (Claros Cuadrado *et al.* 2019), *Myzus persicae* (Koleva-Gudeva *et al.* 2013), *Brevicoryne brassicae, Hellula undalis, Plutella xylostella, Trichoplusia ni* (Baidoo and Mochiah, 2016), *Rhyzopertha dominica, Sitophilus granaries* (Oni, 2011), *Callosobruchus maculatus* (Ileke *et al*. 2013), etc. Our present investigation aimed at studying the bio-efficacy of *C. chinense* against *C. chinensis* under laboratory conditions for the development of ecofriendly and safer management practices in stored green gram.

MATERIALS AND METHODS

The experiment was conducted at the Post Graduate Research Laboratory, Department of Entomology, Assam Agricultural University, during 2018-20. Mature fruits of *C. chinense* were collected from the natural habitats in and around Jorhat district of Assam (Longitude: 94°22′E, Latitude: 26°75′N, Altitude: 91 meters above MSL), dried under shade, ground into finer particles, and sieved with a 150 μm mesh size to obtain a fine powder. The powdered plant products were then stored in airtight glass containers under refrigeration for further use in the experiments.

Mass culture and maintenance of *C. chinensis* on green gram seeds, *Vigna radiata* L. (Variety: Local), which were carefully sorted to eliminate any foreign materials and broken pieces, followed by refrigeration at -20°C for 24 hours to eliminate hidden infestations of storage insect pests (Ingabire *et al.* 2013). One kilogram of green gram seeds was placed into insect rearing plastic containers (Make: General, Capacity: 5 litres), on which 10 pairs of newly emerged adults (1:1 sex ratio) were released for egg-laying and removed after 48 hours of release. The infested green gram seeds were placed on a BOD incubator (30ºC and 80-85% RH) for the emergence of adults and the neonates (1-2 days old) were selected for the bio-efficacy test.

To test the bio-efficacy of *C. chinense* fruit powder against *C. chinensis*, 100 g of un-infested green gram seeds were put into small plastic containers (Make: General, Capacity: 200 ml), whose open tops were covered with muslin cloth for aeration. Afterward, *C. chinense* fruit powder was admixed at different dosage *viz*., 1.0, 2.0, 3.0, 4.0, 5.0, 7.5, and 10.0 g per 100g of seed along with a control for comparison. A total of 20 neonate adults (1: 1 sex ratio) were released onto each of the plastic containers containing *C. chinense* treated green gram seed. Each of the treatments was replicated thrice and the data on adult mortality was recorded at 6, 12, 24, 48, 72, and 96 hours after treatment (HAT). The data on adult mortality (%) was calculated with the formula:

Mortality (%) = (Number of dead insects/Total number of insects inoculated) × 100

In order to evaluate the ovicidal properties of *C. chinense* fruit powder, twenty numbers of neonate adults (1:1 sex ratio) were released into plastic containers containing 100g of green gram seeds for egg-laying. After 12 hours, the adults were removed, and a sample of 10 seeds from each of the replicates, each having at least one egg was selected, marked with a marker and placed back in the containers. Later, *C. chinense* fruit powder was admixed @ 1, 5 and 10 g/100 g of green gram seeds and kept on a BOD incubator (30°C and 80-85% RH) for adult emergence. The data on adult emergence was recorded on obtaining more than 90.0% of adults emergence the control. The percentage (%) of adult emergence was calculated using the formula:

Adult emergence (%) = (Number of adults emerged / Number of eggs laid) × 100

The data so recorded were subjected to Abbott's correction (Abbott, 1925) on obtaining mortality in the control, followed by angular transformation before analysis of variance (ANOVA) with Fisher Test. The data on adult mortality was also subjected to probit analysis to calculate LC_{50} values using SPSS computer software (Version 20.0).

RESULTS AND DISCUSSION

Botanical pesticides or plant-derived products have been the source of attraction in recent times due to the shifting of people's preference towards the consumption of safe and organically grown food products. Plants belonging to the Myrtaceae, Lauraceae, Rutaceae, Lamiaceae, Asteraceae, Apiaceae, Cupressaceae, Poaceae, Zingiberaceae, Piperaceae, Liliaceae, Apocynaceae, Solanaceae, Caesalpinaceae Sapotaceae are known to possess bioactive compounds found effective against several agricultural important insect pests (Srijita, 2015). These plant parts are sometimes dried and ground into fine powder to maximize the exposure and effectiveness against the target pests. In our present investigation, *C. chinense* fruit powder caused as high as 55.00% adult mortality of *C. chinensis* at a dosage 10.0 g/100g of seeds after 96 Hours after Treatment (HAT) as compared 6.67% in the control (Table 1**)**. A minimal adult toxicity (1.67-15.00%) could be seen at 6 hours after treatment across the tested dosage suggesting a low knockdown effect of the product. At 48 HAT, the highest adult mortality of 33.33% was recorded at the dosage of 10.00 g/100 g seed, which was followed by 21.67% and 16.67% adult mortality at the dosage of 7.5 and 5.0 g/100 g seed. A dose- and time-dependent adult mortality was recorded during the experiment, which might be because of increased exposure and accrual of the toxic bioactive compounds over time. As high as 50.00% adult mortality was recorded on administering king chilli fruit powder at the dosage of 10.0 g/100 g seed and the lowest was recorded on application powder at 1.0 g/100 g seed after 72 hours of treatment. The lowest LC_{50} value of 13.04 g/100g seeds (χ^2 = 44.800, Y = -0.161 + 1.393x, p = 0.05) was recorded at 96 HAT (Table 2), which was followed by 17.03 and 59.55 g/100 g seed at

Table 1: Efficacy of king chilli fruit powder on adult mortality of *C. chinensis*

Dosage	Adult mortality (%)					
(g/ 100 g seeds)	6 HAT	12 HAT	24 HAT	48 HAT	72 HAT	96 HAT
10.0	15.00 (32.42)	23.33 (32.42)	26.67 (33.61)	33.33 (37.10)	50.00 (50.22)	55.00 (50.60)
7.5	10.00 (22.89)	11.67 (22.89)	15.00 (22.93)	21.67 (29.68)	35.00 (39.68)	43.33 (45.23)
5.0	6.67 (20.14)	10.00 (20.14)	13.33 (20.11)	16.67 (23.85)	26.67 (33.53)	26.67 (32.40)
4.0	5.00 (18.76)	8.33 (18.76)	11.67 (18.62)	16.67 (23.85)	23.33 (30.59)	23.33 (29.46)
3.0	3.33 (14.91)	6.67 (14.91)	8.33 (13.30)	13.33 (19.99)	21.67 (29.76)	21.67 (28.47)
2.0	3.33 (16.81)	6.67 (16.81)	8.33 (13.30)	13.33 (19.99)	18.33 (26.42)	18.33 (25.10)
1.0	1.67 (14.91)	6.67 (14.91)	8.33 (13.27)	11.67 (18.73)	15.00 (22.86)	16.67 (22.62)
Control	0.00 (0.33)	1.67 (0.33)	5.00 (0.33)	5.00 (0.33)	5.00 (0.33)	6.67 (0.33)
S.Ed. (±)	1.75*	1.75*	2.51*	2.43*	2.38**	1.54**
CD (P=0.05)	3.71	3.71	5.33	5.15	5.05	3.27

Data within parentheses mean of the Abbott's corrected angular transformed values; HAT- Hours after treatment.

Table 2: LC50 values of *Bhut jolokia* (king chilli) fruit powder against *C. chinensis*

Hours after treatment (HAT	LC_{50} values (g/100g seeds)	Regression equation (y = a + bx)	Degrees of freedom (Df)	Heterogenety χ^2	Slope ± S.Em	95% Fiducial limit	
						Lower	Upper
48	59.55	-0.732+0.945x	19	55.654	0.945±0.118	25.55	516.94
72	17.03	-0.272+1.772x	19	44.860	1.177±0.105	11.95	31.17
96	13.04	-0.161+1.393x	19	44.800	1.393±0.107	10.02	19.56

y = probit kill, x = log dose.

72 and 48 hours after treatment, which might be due to presence of capsaicin, n-Hexadecanoic acid, Nonivamide, Pentadecanoic acid, Hexadecenoic acid, Ascorbic acid, Heptadecanoic acid, and Oleic Acid present in the fruits of *C. chinense* (Kundu *et al.* 2025). Paikaray *et al.* (2021) also reported the insecticidal activity of *Capsicum annum* dry fruit powder against *C. chinensis* on green gram under laboratory conditions causing 12.63% adult mortality at 6 Days after treatment (DAT) at a dose of 5 g/kg seed. The mortality of *C. chinensis* was found higher in our present experiment (26.67% @ 5 g/100 kg seed at 96 HAT), which might be attributed due to the presence of higher amount of capsaicin content on the fruits of *C. chinense*. The insecticidal property of *C. chinense* fruit powder has also been reported against *Anopheles gambiae* recording 92% larval mortality at 100 mg/ml concentrations after 24 hours of exposure (Ombugadu *et al.* 2020).

The dry fruit powder of *C. chinense* was also found to possess strong ovicidal properties, significantly reducing the adult emergence of *C. chinensis.* The lowest adult emergence (36.00%) was observed with the dosage of 10.0 g/100.0 g seed as compared to the 91.50% adult emergence in the control experiment (Fig 1.). The ovicidal activity could be attributed to the chemical content of *C. chinense* fruit essential oils including capsaicin and capsaicinoids content, which was found true in the case of *Anopheles gambiae* (Madhumanthy *et al.* 2007). Similarly, Manju *et al.* (2019) also reported a lower adult emergence of *Callosobruchus maculates* (30.00%) on application of fruit powder of *Capsicum annum* at 1.0 dosage. A cessation of adult emergence by 20.00%, 35.00% and 45.00% was also reported by Rosulu *et al.* (2022) with the application of *Capsicum frutescens* fruit powder at a dosage of 1.0 g, 2.0 g and 3.0 g, respectively after 38 days of treatment, which corroborates our present investigation. Foko Dadji *et al*. (2007) also reported the insecticidal properties of red variety of *Capsicum annuum* against aquatic stages of *Anopheles gambiae* with a median inhibitory concentration (IC_{50}) of 13.735 ppm after 24 h exposure. Hence, the *C. chinense* fruit powder could be regarded as a bioactive and ecologically safe alternatives to synthetic insecticides for the control of pulse beetle under storage.

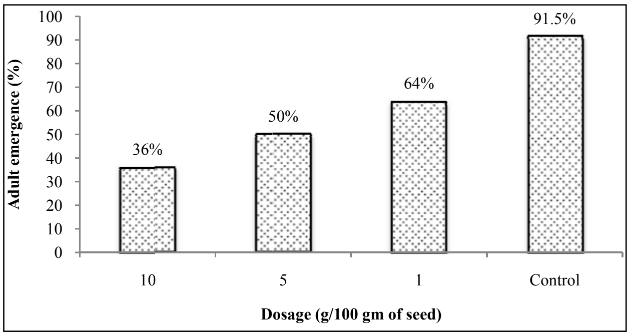

Fig. 1: Ovicidal effect of king chilli fruit powder against *C. chinensis*

CONCLUSION

The dry fruit powder of *C. chinense* has been found to possess strong ovicidal activity along with moderate toxicity to the *C. chinensis* infesting stored green gram, which shows promise for successful integration and incorporation in IPM strategies against storage insect pests after suitable large-scale testing and meticulous standardization of dosage in the near future.

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