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Comparative Efficiency of Certain Indian Spices for Sustainable Management of *Tribolium castaneum* in Stored Wheat

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ABSTRACT: Wheat is a prominent cereal crop cultivated in many countries, from both an economic and nutritional perspective. After harvesting, its grains can be further utilized in multiple ways through long-term preservation. The wheat crop combats a number of difficulties, from sowing to postharvest storage. The major threat that occurs during storage is the infestation of insect pests, which affect both the quality and quantity of grains. *Tribolium castaneum* (Herbst) is one of the serious insect pest of wheat that damage its precious grains in storage. Synthetic insecticides have been widely employed for pest management over a longer period of time, although they pose detrimental effects on the environment and human health. This study has been conducted to promote insect pest management in an ecological manner. For this purpose, laboratory experiments were conducted to assess the efficiency of five Indian spices viz., cinnamon, black pepper, clove, turmeric and bay leaf, at 10 g/Kg dosage against the red flour beetle, *Tribolium castaneum* (Herbst). The observations were made on the basis of percent adult mortality and grain weight loss. The results indicated that all the spice powders effectively caused adult mortality as well as reduced the weight loss of grains compared with the control. However, significant differences were found in the percentage of adult mortality and grain weight loss among treatments. Ultimately, black pepper seed powder was found to be the most effective treatment, resulting in the highest adult mortality and least weight loss, followed by clove, cinnamon, turmeric and bay leaf. The present study demonstrated that botanical powders hold insecticidal properties and could serve as a considerable alternative to chemical insecticides.

KEYWORDS: Wheat, *Tribolium castaneum*, insecticide, spices, mortality.

I. INTRODUCTION

Wheat (*Triticum aestivum*) is consolidated among the major cereal crops, with a yield of around 700 million metric tonnes per year. Its cultivation primarily takes place in tropical, subtropical, and temperate climates. The wheat crop makes a substantial contribution towards the economic section of the country along with imparting nutritional substance to mankind. It is grown in approximately 115 countries, and China, India, and Russia are considered to be the largest wheat-producing countries in the world. It is cultivated on about 29.8 million hectares in India. The northern states of India contribute more to wheat production, in which Uttar Pradesh holds the top ranking with a production of around 25.22 million metric tonnes, while Punjab and Madhya Pradesh lead in the second and third positions with 15.78 and 14.18 million metric tonnes, respectively (Anonymous 2010–2011). Extending food prices are becoming responsible for malnutrition in indigent communities, which has now turned into a global concern that imminently needs to be resolved. However, cereals hold the potential to offer higher dietary content at a lower cost. Wheat is one of these products that incorporates a decent quantity of essential elements, specifically protein, carbohydrates, vitamins, minerals fibers, etc (Sramkova et al., 2009; Biel et al., 2020). As a consequence of its nutritional properties, wheat is further recognized as a poor man's diet. The storage feature of cereals makes them more fundamental among food products. After the harvesting of wheat, its grains can also be stored and consumed as flour, bread, cookies, crackers, pasta, semolina and others. However, during storage conditions, cereals and their byproducts are susceptible to a variety of insects, causing qualitative as well as quantitative losses on grains. Certain species of coleopteran insects, particularly beetles and weevils were found to be associated with stored products, from which *Sitophilus oryzae*, *Rhyzopertha dominica*, *Sitotroga cerealella*, *Callosobruchus chinensis* and *Trogoderma granarium* have been classified as major stored grain pests (Chitra and Subramanian, 2016; Banga et al., 2019). Besides these insects, the red flour beetle, *Tribolium castaneum* (Herbst) is also known to be a significant insect pest of wheat that damages grain

during storage. *Tribolium castaneum* is universal in distribution but is dominantly endured in tropical countries, including India. It is a major pest of wheat, but at the same time, rice, barley, oats, maize and sorghum are also engulfed by their infestation (Weston and Rattlingourd, 2000; Shafique et al., 2006). The larval and adult stages of this beetle have been found as edacious feeders (Pires et al., 2017). Their infestation leads to more than a 30% reduction in quantitative terms. Simultaneously, the commercial value of grains also decreases due to declining their nutritional content. Afterward, they contaminate the product with their feces, sticky secretions and dead bodies, rendering it unsuitable for human consumption. An efficient pest management strategy is highly needed to prevent the spoilage of grains. Synthetic pesticides, usually malathion, lindane, phosphine and pyrethrin have been estimated as appropriate grain protectants (White and Leesch, 2018). However, the extensive application of these chemicals has led to significant pest resistance. Moreover, the toxic residues of pesticides are a subject of major consultation and their extreme abundance in food products poses serious health issues for consumers' health (Nishant and Upadhyay, 2012; Selvaraj et al., 2014). They also affect environmental sustainability by contaminating the natural resources, viz., air, water and soil (Kumar et al., 2013). After suffering the adverse effects of chemicals, attention has now moved toward finding biological alternatives. Over the past few decades, different plants and herbs have constantly been screened to evolve efficient organic pesticides. Plant products are efficacious, easily biodegradable as well as inoffensive towards non-target organisms, which has led to their prominence in modern pest management techniques (Dubey et al., 2010). In this consideration, some Indian spices, which are often applied to food for color and flavor, were evaluated for their efficacy to reduce grain damage. Hence, the major objective of the present study was to compare the efficiency of certain Indian spices as grain protectants for the sustainable management of the red flour beetle, *Tribolium castaneum* (Herbst) in stored wheat.

II. METHODOLOGY

The laboratory experiments were conducted in the Department of Zoology at Dayanand Girls P. G. College, Kanpur, Uttar Pradesh, from the month of August to October 2022. The completely randomized design (CRD) was used during the experiment with three replications.

Collection and Culture of test insect

The culture of *Tribolium castaneum* was initiated by collecting a huge number of adult insects from local godowns in Kanpur. The cumulated insects were examined properly by their taxonomic characteristics (Sreeramoju et al., 2016). After the appropriate recognition, the selected beetles were placed in a plastic container with sterilized wheat grains as their food. The mouth of the container was covered with muslin cloth with the help of rubber bands to prevent the escape of beetles and placed at room temperature. The beetles were allowed to copulate and oviposit in the respective container. After one week of oviposition, the adults were removed from the container and newly emerged beetles were used for further experiments.

Preparation of botanical powders

Five spices, namely cinnamon (*Cinnamomum zeylancium*), black pepper (*Piper nigrum*), clove (*Syzygium aromaticum*), turmeric (*Curcuma longa*) and bay leaf (*Cinnamomum tamala*) (Table 1) were tested for their efficacy against the red flour beetle, *Tribolium castaneum* (Herbst). The locally collected spices were shade dried under room temperature for 7 days, then grounded with the help of an electric grinder and sieved to obtain a fine powder. Pulverized spices were preserved in glass bottles and used for experimentation.

Table 1. Details of spices evaluated for their efficacy against *Tribolium castaneum* (Herbst)

Common name	Scientific name	Parts used	Dosage (g/kg grains)
Cinnamon (Dalchini)	<i>Cinnamomum verum</i>	Bark	10 g
Black pepper (Kali mirch)	<i>Piper nigrum</i>	Seed	10 g
Bay leaf (Tejpatta)	<i>Cinnamomum tamala</i>	Leaf	10 g
Turmeric (Haldi)	<i>Curcuma longa</i>	Rhizome	10 g
Clove (Laung)	<i>Syzygium aromaticum</i>	Bud	10 g

Details of Experiment

Grains of susceptible wheat variety K-88 were procured from the local market and sterilized under an oven at 60 °C for one hour to eliminate visible and hidden infestations of different storage insects. Then clean and disinfected wheat grains were placed in plastic containers, and pulverized spices were separately mixed with grains at a dose of 10 g/kg grains. The required quantity of treated grains was taken from the respective containers and evaluated for adult mortality and weight loss of grains due to insect damage.

Adult mortality

The experiment to calculate adult mortality was conducted in separate plastic containers with 50 g of treated grains at 10 g/kg dosage, including untreated control. Ten pairs of newly emerged adult beetles were released in each container and the mouths of the containers were tied with muslin cloth with the help of rubber bands to prevent the escape of beetles and placed at room temperature for observation. The experiment was replicated thrice and containers were labeled appropriately to identify the treatments. Insects were observed daily and dead adults were counted and removed from containers to ensure accurate measurements. The observations on adult mortality were recorded for each treatment after 1, 2, 3, and 4 days of exposure by using the following formula (Abbott, 1925).

Corrected mortality (%) = $(1 - \text{Number of live adults in treatment} / \text{Number of live adults in control}) \times 100$

Weight loss

A further set of experiments was conducted to assess the losses in grains treated with different spice powders. For this purpose, ten pairs of adults were released in containers containing 50 g of treated grains at 10 g/kg dosage with different grain protectants along with untreated control. The containers were kept at room temperature without disturbance for the appropriate duration. After 60 days, the weight of infested grains was measured using an electronic weighing balance after the removal of all dust and insect life stages. The difference between the initial and final weights was considered a loss of weight in grains and the percentage of loss was determined by using the following formula:

Weight loss (%) = $\frac{\text{Initial weight} - \text{final weight}}{\text{Initial weight}} \times 100$

Statistical Analysis

The data obtained from laboratory experiments were statistically analyzed using analysis of variance (ANOVA). The data on percent adult mortality and percent weight loss was transformed to arc-sine values and critical differences (C.D.) were computed at a 5% level of significance. Microsoft Excel was used to interpret the data in tables and graphs.

III. RESULTS AND DISCUSSION

The data recorded during the investigation on adult mortality of *Tribolium castaneum* due to different spice powders are presented in (Table 2). The statistical data manifested that all the treatments were found to be efficacious with respect to adult mortality. The observations on mortality were made at 1, 2, 3 and 4 days after treatment and its percentage was found to increase with days of exposure. The highest mean adult mortality at 1 DAT was recorded in grains treated with black pepper (16.67%). It was followed by clove (11.67%), cinnamon (8.33%), turmeric (6.67%) and bay leaf (3.33%). There was no adult mortality observed in the untreated control. At 2 DAT, the mortality percentage ranges from 8.47 to 38.98 in grains treated with different spice powders, from which the maximum adult mortality was recorded in black pepper (38.98%) followed by clove (32.20%), cinnamon (23.72%), turmeric (18.64%) and bay leaf (8.47%). Whereas, the untreated control shows (1.67%) mortality. At 3 DAT, the maximum adult mortality was recorded in grains treated with black pepper (66.10%), followed by clove, cinnamon, turmeric and bay leaf with 55.93, 42.37, 30.50, and 16.94 percent mortality rates, respectively. The untreated control remained equivalent to the above storage period, where the mortality was observed 1.67 percent. The highest mortality percentage was recorded at 4 DAT, where black pepper was found to be the most efficient and superior to other treatments with (71.93%) mortality rate. The second best treatment was clove, with (64.91%) mortality, followed by cinnamon (54.38%) and turmeric (36.84%), although minimum mortality was observed in bay leaf (21.05%). Whereas, (5.00%) mortality was recorded in the untreated control. The results indicated that all the spice powders were found to be effective in causing mortality against *Tribolium castaneum*. However, the overall highest mortality percentage for each day was observed in black pepper, followed by clove, cinnamon, turmeric and bay leaf. The current observations are supported by the study of (Shayesteh and Ashouri, 2010; Saeed et al., 2016), who reported that the seed powder of black pepper comprises strong repellent properties against *Tribolium castaneum* (Herbst).

Table 2. Efficacy of spice powders on adult mortality of *Tribolium castaneum* (Herbst)

Treatments		Number of adults Released	Percent Mortality			
Name	Symbol		1 DAT	2 DAT	3 DAT	4 DAT
Cinnamon	T1	20	8.33 (16.73)	23.72 (29.14)	42.37 (40.54)	54.38 (47.47)
Black pepper	T2	20	16.67 (24.07)	38.98 (38.60)	66.10 (54.39)	71.93 (57.99)
Bay leaf	T3	20	3.33 (10.48)	8.47 (16.91)	16.94 (24.26)	21.05 (27.25)
Turmeric	T4	20	6.67 (14.95)	18.64 (25.53)	30.50 (33.50)	36.84 (37.30)
Clove	T5	20	11.67 (19.93)	32.20 (34.54)	55.93 (48.33)	64.91 (53.61)
Control	T6	20	0.00 (0.00)	1.67 (7.41)	1.67 (7.41)	5.00 (12.88)



SE(m)±	-	-	0.44	0.52	0.39	0.47
CD at 5%	-	-	0.96	1.13	0.85	1.02

DAT- Day after treatment *The data represented in the table is the mean of three replications

**Figures in parentheses are arc-sine transformed values

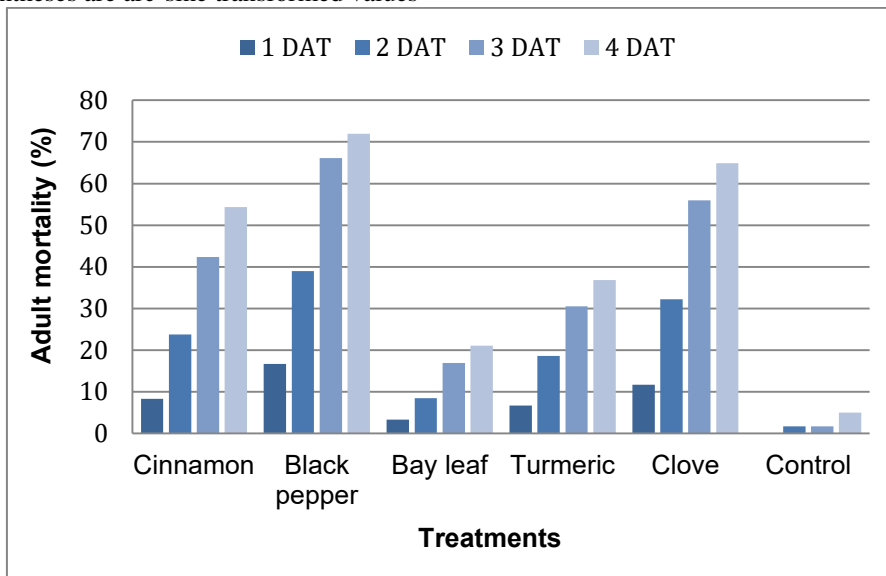


Figure 1. Adult mortality of *Tribolium castaneum* (Herbst) by different spice powders

Similarly, the data recorded during the investigation on percent weight loss due to *Tribolium castaneum* under the influence of different spice powders are presented in (Table 3). After 60 days of storage, significant differences were found in the weight of grains treated with different spice powders. The weight reduction ranged from 2.26 to 10.24 percent, including untreated control. Among different treatments, the least weight loss was recorded in grains treated with black pepper (2.26%). Whereas maximum weight loss was recorded in the untreated control (10.24%), it was followed by bay leaf (6.32 %), turmeric (4.22%), clove (4.06%) and cinnamon (3.56%). Similar findings were observed by (Aslam et al., 2002) who reported that chickpea seeds were least affected by *Callosobruchus chinensis* when treated with black pepper and clove powders.

Table 3. Effect of spice powders on grain weight loss due to *Tribolium castaneum* (Herbst) after 60 days

Treatments		Initial weight of grains (in gm)	Final weight of grains after 60 days	Weight loss in (%)
Name	Symbol			
Cinnamon	T1	50 g	48.22	3.56 (10.83)
Black pepper	T2	50 g	48.87	2.26 (8.62)
Bay leaf	T3	50 g	46.84	6.32 (14.53)

Turmeric	T4	50 g	47.89	4.22 (11.82)
Clove	T5	50 g	47.97	4.06 (11.59)
Control	T6	50 g (untreated)	44.88	10.24 (18.66)
SE(m)±	-	-	-	0.01
CD at 5%	-	-	-	0.03

*The data represented in the table is the mean of three replications

**Figures in parentheses are arc-sine transformed values

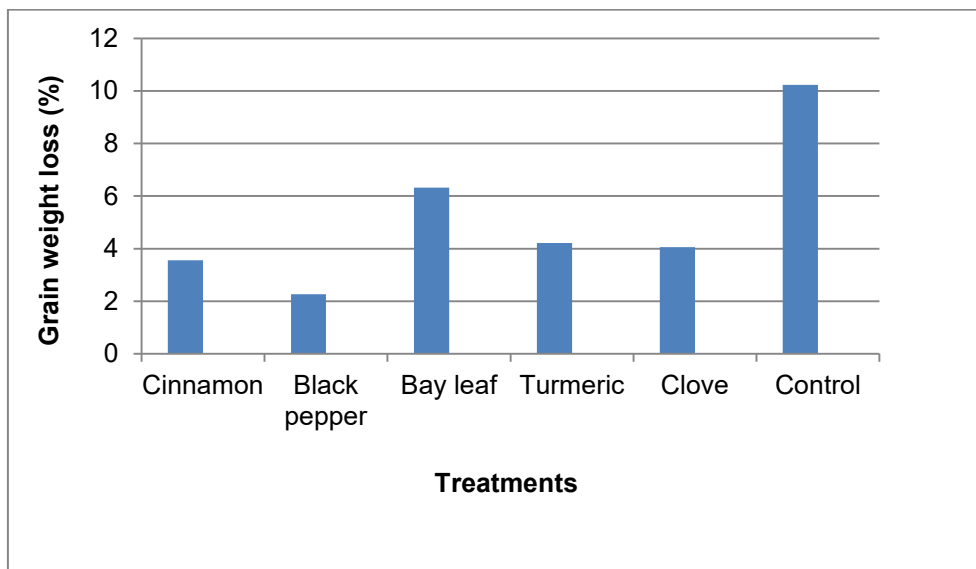


Figure 2. Weight loss of grains due to *Tribolium castaneum* as influenced by different spice powders

IV. CONCLUSION

Tribolium castaneum (Herbst) is a hazardous insect pest of wheat that destroys nutritious food grains in storage as a result of its feeding activity and contamination. Although synthetic insecticides are effective in resolving this concern, they are harmful to the environment. This research work led to the conclusion that pulverized spices could be a decent alternative to chemical-based insecticides. They furnish eco-friendly and sustainable means of grain protection against *Tribolium castaneum* in stored wheat. This study promotes organic pest management strategies to secure food materials during storage.

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