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Effectiveness of Pure Capsaicin as Aversive Agent against House Rat, *Rattus rattus*

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KEY WORDS

Antifeedant

Aversive effect

Capsaicin

Rattus rattus

Rodents

ABSTRACT The house rat (*Rattus rattus)* is the most destructive commensal rodent pest. The use of rodenticides is the most commonly used method for the control of rodents. However, the drawbacks of using rodenticides such as nontarget toxicity, environmental hazards, and development of resistance have increased the search for plant products acting as repellents or antifeedants against rodent pests. Capsaicin is the active ingredient of red chilli responsible for causing irritating and pungent effects. The present study was conducted to evaluate the aversive effect of pure capsaicin against both sexes of house rat, *R. rattus*. Different groups of rats were fed on baits containing 0.01 and 0.03% pure capsaicin for a total of 14 days with a gap period of 7 days in bi-choice feeding tests. Rats of the control group were fed on plain bait. Results showed that mean daily consumption of treated bait was significantly ($P \leq 0.05$) low from that of untreated baits indicating the aversive effect of the capsaicin. There was a significant difference in the antifeedant index ($P \leq 0.05$) between 0.01% and 0.03% concentration showing higher aversion at 0.03% of pure capsaicin.

INTRODUCTION

Rodents cause significant damage to agricultural crops. Annual loss of about 77 million tons by rodent pests is observed at pre-harvest stage around the world (John, 2014). According to an estimate, rodents cause 25% loss of food grains at pre-harvest and 25–30% at post-harvest situations, leading to the loss of about US$5 billion annually in India (Hart, 2002). Irregular rodent outbreaks are responsible for extreme crop losses of about 30–100% (Singleton *et al.,* 2010). Rats (*Rattus* spp.) are common and most destructive invasive pests found throughout the world (Quinn *et al.,* 2014). They cause severe damage in storage houses by feeding on the stored food material and also by contaminating it with their excrement, thereby making it unfit for human consumption (Drummond, 2001; Brown *et al.,* 2007). Poultry farms in India are found heavily infested with *Rattus rattus* (Sridhara and Krishnamurthy, 1992). At present, chemical rodenticides, fumigants, mechanical barriers, habitat manipulation, and trapping are the strategies used to control rodents; the rodenticides being the most commonly used method for their control. However, the drawbacks of using rodenticides such as nontarget toxicity, environmental hazards, and development of resistance have made researchers to look for plant products that may act as repellents or antifeedants. The repellents/aversive agents stimulate

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the primary or secondary defense mechanisms in animals causing rejection of food.

Capsaicin is the pungent principle of hot peppers of the genus *Capsicum*. Capsaicin and many other similar compounds called capsaicinoids are secondary plant metabolites of hot chilli pepper which may be produced as deterrents against herbivores (Srinivasan, 2015). Capsaicin is a naturally occurring, noncarcinogenic biopesticide (US Environmental Protection Agency, 1992 a,b), obtained by grinding dried chilli and then formulating these particles in a liquid, aerosol, or another carrier (Sterner *et al.,* 2005). The potential of poultry feed containing capsaicin as an aversive agent against rodents and its efficacy in enhancing its acceptability as rodenticides in poultry farms was reported earlier (Jensen *et al.*, 2003). The use of capsaicin-treated feed in poultry farms could significantly reduce food intake of rodents, and subsequently, the contamination of poultry feed that has been responsible for infectious diseases to poultry (Vicente *et al.,* 2007). The present study is the first of its kind from India reporting the efficacy of capsaicin as an aversive agent against *R. rattus* and its role in enhancing the rodenticide bait efficacy against rats under laboratory conditions.

MATERIALS AND METHODS

Pure capsaicin used in present study was procured from M/s Sigma-Aldrich Chemicals Pvt. Ltd., India.

Collection and Maintenance of Animals

For the present study, the male and female house rat, *R. rattus* were live-trapped from poultry farms at Ludhiana. In the laboratory, rats were acclimatized individually in cages for 15–20 days before the commencement of the experiment. Food (loose mixture of cracked wheat, powdered sugar, and groundnut oil [WSO bait] in the ratio of 96:2:2) and water were provided *ad libitum*. After acclimatization, healthy and mature rats were weighed and grouped for experimentation. Animals were maintained as per the guidelines of the Institutional Animal Ethics Committee.

Treatment

Rats were divided into three groups of five animals each. Rats of Groups I and II were fed on WSO bait containing 0.01 and 0.03% pure capsaicin, respectively, in bi-choice with plain WSO bait for 2 weeks with an intervening period of 1 week. Rats of Group III were fed on plain WSO bait. Bait consumption was recorded daily after every 24 h and from the amount of bait consumed; antifeedant index (%) was calculated as per the method described in Singla and Parshad (2007).

$$\text{Antifeedant index} = \frac{\text{Consumption of untreated bait} - \text{Consumption of treated bait}}{\text{Consumption of untreated bait} + \text{Consumption of treated bait}} \times 100$$

Statistical Analysis

Data are expressed as a mean ± standard deviation. The data on food consumption for two sexes, two concentrations of capsaicin, 7 days of exposure and from treated and untreated replicates were recorded using factorial experiments in completely randomized design. All pairwise treatment comparisons were made using Tukey's honest significant difference test. $P \leq 0.05$ was considered statistically significant.

RESULTS AND DISCUSSION

Aversive Effect of 0.01% Capsaicin

Exposure of bait containing 0.01% pure capsaicin in bi-choice with plain WSO bait revealed significantly ($P \leq 0.05$) low mean daily consumption (g/100 g bwt) of treated bait compared to untreated bait by both male and female rats during the first as well as second treatment weeks indicating the aversive effect of capsaicin. During the 1st week of treatment, the mean daily consumption of treated bait by both male and female rats was almost same on all the 7 days, i.e., there was no significant difference in bait consumption among all the 7 days. During the 2nd week of treatment also in both male and female rats, there was no significant difference in consumption of treated bait among all the 7 days indicating no habituation in rats in response to first exposure to the capsaicin-treated bait.

Aversive Effect of 0.03% Capsaicin

Exposure of bait containing 0.03% pure capsaicin in bi-choice with plain WSO bait revealed significantly ($P \leq 0.05$) low mean daily consumption (g/100 g bwt) of treated bait compared to untreated bait by both male and female rats during the first as well as second treatment weeks indicating the aversive effect of capsaicin. During the first treatment week, the mean daily consumption of treated bait by female rats on day 1 was 0.69 g/100 g bwt which decreased to almost nil by day 7. In male rats, the mean daily consumption of treated bait on day 1 was 0.45 g/100 g bwt, which also decreased to almost nil by day 7. During the

second week of treatment, the mean daily consumption of treated bait by female rats on day 1 was 0.31 g/100 g bwt which decreased to almost nil by day 7. In male rats, the mean daily consumption of treated bait on day 1 was 0.22 g/100 g bwt, which also decreased to almost nil by day 7. This again indicates no habituation in rats in response to first exposure to the capsaicin-treated bait.

During treatment week I, the average antifeedant index of pure capsaicin in female rats was found to be significantly ($P \leq 0.05$) higher at 0.03% capsaicin (72.70–98.80%) compared to that at 0.01% capsaicin (23.80–83.41%). In male rats also, the antifeedant index at 0.03% capsaicin was significantly ($P \leq 0.05$) higher (75.20–98.57) than that observed with 0.01% capsaicin (31.80–89.89) (Table 1). During treatment week II also, the average antifeedant index of capsaicin in both male (80.97–100%) and female (90.55–94.75%) rats was significantly higher at 0.03% capsaicin. Average antifeedant index was 54.57–59.85% during the first treatment week and 42.40–42.66% during the second treatment week at 0.01% capsaicin. Average antifeedant index was 89.51–95.70% during the first treatment week and 91.78–92.18% during the second treatment week at 0.03% capsaicin. Overall, there was a significant difference ($P \leq 0.05$) in the antifeedant index of capsaicin between the two concentrations in rats of both sexes during the treatment weeks I and II (Fig. 1). The difference in the antifeedant index was nonsignificant between the two treatment weeks in rats of both sexes and at both the concentrations (Fig. 2). No sex-specific differences in the antifeedant effect of pure capsaicin were observed.

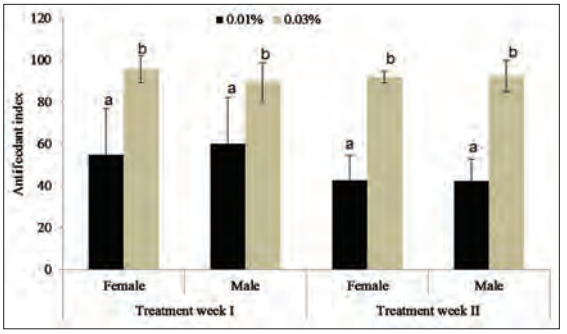

Fig. 1. Comparison of antifeedant index of pure capsaicin between two concentrations during treatment weeks I and II in male and female *Rattus rattus*. [a,b]Bars not sharing common superscripts indicate significant differences ($P \leq 0.05$).

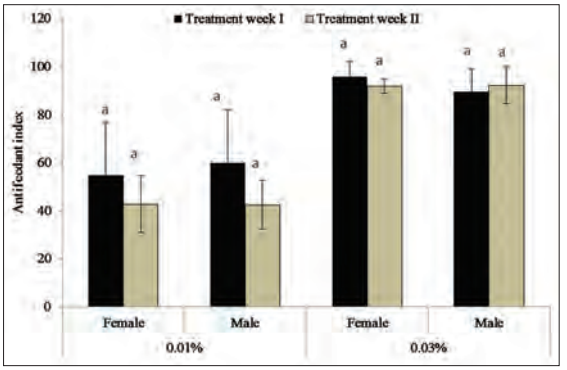

Fig. 2. Comparison of antifeedant index of different concentrations of pure capsaicin in male and female *Rattus rattus* between treatment weeks I and II. [a]Bars sharing common superscript indicate no significant differences ($P \leq 0.05$).

Table 1. Feeding deterrent effect of capsaicin at 0.01 and 0.03% concentrations against *Rattus rattus* of both sexes during the first and second treatment week (n=5 each; mean±SD)

Days	Antifeedant index (%)							
	Treatment period I				Treatment period II			
	Female rats		Male rats		Female rats		Male rats	
	0.01%	0.03%	0.01%	0.03%	0.01%	0.03%	0.01%	0.03%
Day 1	59.12±33.84^{a}	72.70±6.66^{b}	58.07±34.44^{a}	77.88±4.86^{b}	62.89±22.39^{a}	87.04±13.21^{b}	31.05±13.65^{a}	81.75±20.09^{b}
Day 2	59.68±46.59^{a}	89.82±10.27^{b}	89.89±17.32^{a}	75.20±8.97^{b}	51.23±20.10^{a}	90.74±8.60^{b}	52.92±9.45^{a}	94.23±7.92^{b}
Day 3	44.16±40.84^{a}	98.42±3.52^{b}	83.02±28.87^{a}	90.36±9.00^{a}	36.10±14.75^{a}	92.77±7.39^{b}	41.48±12.07^{a}	97.31±6.01^{b}
Day 4	83.41±15.77^{a}	94.52±7.54^{a}	59.99±22.15^{a}	95.52±6.31^{b}	38.13±18.14^{a}	94.75±11.72^{b}	39.98±7.60^{a}	80.97±7.77^{b}
Day 5	78.71±30.63^{a}	98.80±2.67^{b}	63.57±9.03^{a}	93.34±9.17^{b}	30.08±12.01^{a}	90.86±10.04^{b}	34.55±14.01^{a}	94.12±8.06^{b}
Day 6	33.12±8.38^{a}	95.78±6.31^{b}	32.67±13.86^{a}	98.57±3.18^{b}	47.92±14.75^{a}	95.75±6.09^{b}	37.25±9.97^{a}	100±0^{b}
Day 7	23.80±10.99^{a}	97.17±6.31^{b}	31.80±15.99^{a}	95.70±6.39^{b}	32.29±15.04^{a}	90.55±10.23^{b}	59.63±7.47^{a}	96.92±6.88^{b}
Average	54.57±22.27^{A}	95.70±6.39^{B}	59.85±22.29^{A}	89.51±9.23^{B}	42.66±11.83^{A}	91.78±2.92^{B}	42.40±10.25^{A}	92.18±7.66^{B}

[a,b]Mean values not sharing common superscripts in a row for each sex indicate significant difference ($P \leq 0.05$). [A,B]Average of mean values not sharing common superscripts in a row for each sex indicate significant difference ($P \leq 0.05$). [a]Mean values sharing similar superscript in a column for treated bait indicate no significant difference ($P \leq 0.05$)

During the present study, significantly low consumption of bait treated with different concentrations of pure capsaicin from that of untreated bait was observed. This showed secondary repellent effect caused after experiencing post-ingestional deleterious changes. Furthermore, there was a decrease in consumption of treated bait from days 1 to 7, indicating learnt aversion in rats. Similar type of secondary repellent effect of few plant products was also studied earlier (Sayre and Clark, 2001), and it was more effective than primary repellent effect as it causes aversive effect for a longer duration of time depending on the severity of post-ingestional effects of the product (Dolbeer *et al.*, 1994). The potential of sprays formulated using natural products containing 2% red chilli powder and 0.3% capsicum oleoresin as aversive agents in reducing rodent damage under simulated store conditions has been reported by us earlier (Kaur and Singla, 2017).

Capsaicin is apparently generalist repellent to mammals causing post-ingestion effects on feeding (Mason *et al.*, 1991; Ritter and Taylor, 1989). Hot sauces containing capsaicin were used as repellents against mammals in USA (Andelt *et al.*, 1994). Mason *et al.* (1991) reported that badgers ate capsaicin and untreated baits with equal eagerness on day 1 of treatment night, which showed that capsaicin was not immediately aversive to treated animals. Repellents used for the control of vertebrate pests depends on the generation of a conditioned taste aversion (CTA) in response to post-ingestional effects and feeling of illness experienced after ingestion (Provenza, 1995; Cowan *et al.*, 2000). Mammals mostly developed aversion against foods or liquids of specific tastes in wild and also in the laboratory. Gustavson *et al.* (1976) studied that when CTA develops to any repellent, the target animal would have to eat the food each time before being averted. Such repellents causing post-ingestion malaise can act as alternatives to synthetic pesticides (Ballesta-Acosta *et al.*, 2008). The present findings revealed a change in the behavior of rats in response to exposure to the capsaicin-treated bait. Furthermore, rats did not retain the memory of first exposure to capsaicin as there was no significant difference observed in antifeeding index between the two treatment periods in all the three treatment groups. During the second treatment period, bait containing capsaicin was avoided by rats in a similar way as in the first treatment period.

In conclusion, 0.03% pure capsaicin is an aversive agent against *R. rattus*, thus suggestive of its possible use on a larger scale under field conditions by mixing in food or applied to food containers in poultry farms and storage.

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