

THE EFFICACY OF A TRACKING-EDIBLE ZINC PHOSPHIDE/MOLASSES GEL DELIVERY SYSTEM FOR CONTROLLING ROOF RATS COMPARED WITH A TRADITIONAL METHOD

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Abstract

The present study was carried out as an attempt to overcome bait shyness developed by rats when they ingest sub-lethal doses of rodenticides. It depends on incorporating a rodenticide with a gel contaminant. Contaminated rodents would then ingest the toxicant during grooming and die. The efficacy of a tracking-edible zinc phosphide/molasses gel delivery system was tested through non-choice and free-choice laboratory feeding tests. In non-choice tests, the results indicated that the consumption of plain molasses gel equals 6.6% of the average individual body weight, while the consumption of the toxicant/gel bait equals 7.5% of that weight. The average daily amount of zinc phosphide ingested, in the form of toxicant/gel bait, was 68.4 mg/ a rat. Rat mortality was 75% over 2 days. In free-choice tests, the average daily consumption of plain molasses gel was 48.7% of that of crushed maize, and its acceptability was 32.9%. The average daily consumption of the toxicant/gel bait was 56% that of crushed maize. The daily amount of zinc phosphide ingested by individual rats was 21 mg/individual rat. This amount was sufficient to kill 50% of tested caged rats. The acceptability of the gel/ toxicant bait was 36.2%. The average daily consumption of 0.5% zinc phosphide/crushed maize bait was lower than the average daily consumption of plain crushed maize. The acceptability and mortality were 19.3% and 33.3%, respectively. The results of the present study indicate that the acceptability, against plain crushed maize, of the toxicant/gel was about twice that of the toxicant/crushed maize and that the mortality among rats exposed to the toxicant/gel bait was higher than that among rats exposed to toxicant/crushed maize bait.

INTRODUCTION

The traditional methods of the control of roof rats and other commensal rodents include the use of the acute poison zinc phosphide, which has been used since the 1940's, and is presently still being used. Extensive laboratory and field studies have been conducted on its effect on roof rats and other commensal rodents (Eisemann *et*

al., 2003). One of the problems associated with the use of this poison, and other acute poisons, is that rodent pests frequently developed bait shyness when they consume sublethal doses of such poisons. To overcome this problem, rodents were contaminated with a zinc phosphide formulation which was then ingested when they groomed their fur (Soliman, 1989). Grooming behavior might, thus, be used to deliver toxicants for crop protection (Reidinger and Mason, 1986). The behavior and the physiological basis of grooming have been investigated by various authors (Colbern *et al.*, 1978; Dunn *et al.*, 1979; Geyer and Kornet, 1982; Cohen and Price, 1979; Mason *et al.*, 1985 and Reidinger and Mason, 1986). Reidinger and Mason (1983) referred to the physiological basis of grooming in rodents. They indicated that grooming an aversive tastant from the fur was associated with increased blood levels of corticosteroids which are believed to stimulate grooming in rodents. Thus grooming results in the perception of the aversive tastant, and perception of the aversive tastant results in more grooming and so on. Mason *et al.* (1982) earlier indicated that taste aversion can be observed during hetero-grooming of a cage mate but not during autogrooming or self-grooming.

Non-choice and free-choice feeding tests were carried out in the laboratory to evaluate the acceptability of plain molasses gel and toxicant/gel formulation. The daily amounts of the gel/toxicant formulation consumed by individual rats were compared to the amounts of crushed maize/toxicant formulation, as traditional bait, consumed by these rats. The efficacy of a tracking-edible zinc phosphide/molasses gel delivery system was tested.

MATERIALS AND METHODS

1. Test animals

A total of 30 roof rats, *Rattus rattus*, were used in the present study. Rats were housed in wire cages (50 x 30 x 20 cm), and observed for at least 2 weeks before treatment. Food and water were provided to rats *ad libitum*.

2. Preparation of molasses gel

The method used by Soliman (1988) for preparing of molasses gel tests used by some modifications. The gel prepared consisted of wheat flour, margarine, and molasses mixed together in the following proportions by parts: 3:1:6. The gel was prepared according to the following steps:

Flour was carefully mixed with margarine in an operineum for one minute. Molasses was then added and mixed carefully for 3 minutes.

The prepared molasses gel has the following characters:

- 1- It is prepared from locally available and inexpensive ingredients.
- 2- Tacky for about 60 days.
- 3- Not having repellent qualities.

3. The delivery system and the preparation of toxicant/gel formulation

A plastic tube, 20 cm long and 5.5 cm inner diameter was used for providing either the molasses gel or the toxicant/gel formulation to caged test rats. In the present study, zinc phosphide was used in a concentration of 0.5% in molasses gel (i.e., 5 mg zinc phosphide/g gel). The LD₅₀ of zinc phosphide in case of roof rats is 21.3 mg/kg body weight (Hilton, and Robin, 1972).

4. Testing the efficacy of toxicant/gel delivery system using non-choice feeding tests

A known amount (30 g) of each of plain molasses gel and poison/gel bait was evenly applied to the inner surface of each of the plastic tubes using a spatula, and one tube was presented to each caged rat. Eight rats were tested with each of the plain molasses gel and 0.5% zinc phosphide/molasses gel formulation, in 24hr non-choice tests. Water was provided *ad libitum* for rats. The daily amounts of each of the plain molasses gel and zinc phosphide/molasses gel bait removed by individual rats, and the occurrence of rat mortalities were recorded.

5. Testing the efficacy of toxicant/gel delivery system using free-choice feeding tests: comparison between molasses gel and crushed maize formulations

Free choice feeding tests were carried out according to the following steps:

1. A known amount (30g) of crushed maize (a), placed in a dish, and a known amount (30g) of plain molasses gel (b), evenly applied to the inner surface of a plastic tube, were provided daily to each of 8 caged rats for 4 days. Water was provided to rats *ad libitum*.
2. A known amount (30g) of 0.5% zinc phosphide/molasses gel (c) and a known amount (30g) of crushed maize (a), placed in a dish, were presented daily to each of 8 caged roof rats for 2 days.
3. A known amount (30 g) of each of crushed maize (a), and 0.5% zinc phosphide/crushed maize (d) were daily presented to 6 roof rats for 2 days.

The daily amounts of each of (a), (b), (c), and (d) removed by individual rats were estimated. The acceptability and mortality of rats were calculated. Rats were noticed for seven days after treatment.

The acceptability, by rats, of any bait formulation or food material (1) relative to another such material (2) in non-choice or free-choice feeding tests was calculated according to the following equation (Mason *et al.*, 1989):

$$\text{Acceptability of "1" (\%)} = \frac{\text{Average daily consumption of "1" (g)}}{\text{Average total daily consumption of "1+2" (g)}} \times 100$$

RESULTS

1. Non-choice test:

Results of the application of both plain molasses gel and 0.5% zinc phosphide/molasses gel formulation to caged rats showed that the average daily consumptions of molasses gel (control) and 0.5% zinc phosphide/molasses gel formulation were 12.8g and 13.7g, respectively (Table 1). The difference between these amounts is statistically insignificant. These amounts represent 90% of actually recorded ones. It is supposed that 10% of the gel was lost during testing. The average daily consumption of toxic molasses gel is thus 107% of the consumed amount of plain molasses gel (control). The daily consumptions of plain molasses gel and toxicant/ gel formulation were 6.6% and 7.5% of the average individual body weight.

Rat mortality was 75% over a period of 2 days after the application of poison/gel formulation. The average amount of zinc phosphide ingested by individual rats was thus 68.4 mg/individual. This amount of zinc phosphide equals 17.7 LD₅₀, expressed as mg/kg body weight. The acceptability of the gel/toxicant formulation was 51.7% (Table 1).

2. Free-choice test

Results of the application of molasses gel and crushed maize to caged rats in free choice tests showed that the average daily consumption of molasses gel was 49.1% of that of crushed maize (Table 2). It should be noticed that the amount of consumed molasses gel is considered to be 90% of its actually recorded amount. The average daily amounts consumed by individual rats were 12.1 g and 5.9g for crushed maize and plain molasses gel, respectively. The acceptability of molasses gel, relative to crushed maize, was 32.7%. The average daily consumption of crushed maize was higher than that of molasses gel.

Results of the application of 0.5% zinc phosphide/molasses gel formulation to caged roof rats in free-choice tests indicated that the average daily consumption of the toxicant/gel formulation was 56.7% that of crushed maize (Table 3). The average daily amounts consumed by individual rats were 7.5 g and 4.2 g for crushed maize and the toxicant/gel formulation, respectively. It should be noticed that the amount of consumed toxicant/gel formulation is considered to be 90% of its actually removed amount. It contains an average amount of zinc phosphide that equals 5.6 LD₅₀ expressed as mg/kg body weight. This amount was sufficient to kill 50% of caged test rats. The acceptability of the gel/toxicant formulation, relative to crushed maize, was 36.2%.

Results of the application of 0.5% zinc phosphide/crushed maize formulation to caged roof rats in free-choice test are presented in. showed that The average consumed daily amounts of 0.5% zinc phosphide/crushed maize and plain crushed maize were 0.8g and 3.4g, respectively (Table 4). The average daily consumption of 0.5% zinc phosphide/crushed maize formulation by rats was thus 24% the average daily consumption of plain crushed maize. The acceptability and mortality were 19.3% and 33.3%, respectively. The average daily consumption of crushed maize was significantly higher than that of crushed maize/zinc phosphide formulation in free choice test.

The obtained results indicated that the acceptability of 0.5% zinc phosphide/molasses gel formulation was about twice that of 0.5% zinc phosphide/crushed maize baits. The acceptabilities of the toxicant/gel formulation and toxicant/crushed maize baits were 36.2% and 19.3%, respectively.

The mortality among rats treated with toxicant/gel formulation was 1.5 times higher than that among rats treated with zinc phosphide/crushed maize baits. The mortalities were 50% and 33.3% among rats treated with toxicant/molasses gel formulation and 0.5% toxicant/crushed maize baits, respectively.

DISCUSSION

One approach to overcome bait shyness in rodents, or the presence of an alternative food, is to contaminate them with a toxic formulation which is then ingested during grooming (Sanchez, 1977; Poché *et al.*, 1979; Fellows, 1980). The use of contact poison/gel formulation is preferred in many situations because it is generally safer than dusts since it is less mobile and spillages are more easily cleared. The placement of a gel is more precise and its active ingredient is often less concentrated than that of dusts (Meehan, 1984).

Early laboratory and field trials were done for presenting rodenticides to rats through their grooming behavior. Poché *et al.* (1979) applied zinc phosphide/grease formulations to the bamboo sticks in the entrances of the burrows of the lesser bandicoot rat, *Bandicota bengalensis* in Bangladesh, but the results were not encouraging. Automotive grease/zinc phosphide and used motor oil/zinc phosphide formulations were also applied to banana leaves and to tiles and put along the runways of *Rattus rattus mindanensis* in rice paddies in the Philippines (Sanchez, 1977; Fidler, 1979, 1983). Morris *et al.* (1983) developed a brodifenacoum containing wick device and evaluated its use for the control of commensal house mice. Reidinger, Jr. (1985) invented a method and apparatus for automatically dispensing a measured amount of a rodent control liquid onto the dorsal fur of rodents. Soliman (1988) developed simple devices for contaminating rats and mice with toxicant/gel

formulations, and tested both molasses gel and petroleum jelly as potential gels for contaminating albino rats and mice. He found that molasses gel was more readily removed by these rodents than petroleum jelly.

Zinc phosphide, as an acute poison, is used here for the preparation of a toxicant/gel formulation. This rodenticide has been used for several decades for controlling rodents and other vertebrate pests. This is because this poison has low risk of secondary poisoning, and is not environmentally persistent (Anonymous, 2011). According to the same author, it is planned that the use of this poison in both paste and solid cereal baits will be extended to control rodents and other vertebrate pests in New Zealand.

The results of the present study indicate that the use of zinc phosphide/molasses gel formulation has resulted in higher mortalities among roof rats than among rats treated with zinc phosphide/crushed maize baits.

In non-choice tests, the average daily consumption of toxic molasses gel was 107% of the consumed amount of plain molasses gel, and the daily consumption of each of plain molasses gel and toxicant/gel formulation were 6.6% and 7.5% of the average individual body weight. These ratios are considered as high ones since rats normally consume a quantity of food materials that equals 10% of their body weight (Meehan, 1984). This means that plain molasses gel as well as the toxicant/gel formulation are readily accepted and removed by caged roof rats.

In free-choice tests, the average daily consumption of crushed maize was higher than that of molasses gel, and the acceptability of molasses gel, relative to crushed maize, was 32.9%. These results are comparable to the results of Soliman (1989) who indicated that wild Norway rats, *Rattus norvegicus*, preferred wheat grains than molasses gel in simulated grain store studies. The mortalities among these rats, which did not show signs of active removal of the toxicant/gel formulation, were 46%. Preliminary studies conducted by Soliman and Daoud (2004) on the use of a zinc phosphide/molasses gel delivery system in the control of the roof rat, *R. rattus* gave promising results.

A zinc phosphide/gel formulation was also tested for the control of other vertebrate pests (possums) in New Zealand. The results indicated that majority of possums tested have ingested the poison while grooming the toxic gel, and died (Blackie *et al.*, 2016).

The tubes used here for delivering the toxic gel to roof rats proved to be successful in this respect. They were listed among the bait stations currently used in the control of rodents (O'Connor and Eason, 2000).

Table 1. Results of the application of plain molasses gel and 0.5% zinc phosphide/molasses gel formulation to caged roof rats in non-choice feeding tests. Average is followed by \pm S.D., and range in (parentheses).

Applied food	No. of individuals	Average body weight (BW) (g)	Average daily consumption (g)		Average amount of ingested zinc phosphide (mg)	Average daily ingested zinc phosphide in relation to BW (mg/kg)	Acceptability (%)	Mortality (%)	
			Total	90% of consumed gel				No.	%
Plain molasses gel	8	192.5 \pm 44.64 (120-240)	14.21 \pm 6.35 (2.4-20) ^{ns}	12.79					
0.5% zinc phosphide molasses gel formulation	8	181.25 \pm 34.41 (130-250)	15.20 \pm 6.87 (5.0-20) ^{ns}	13.68	68.40	377.38	51.68	6	75

The vertical columns marked with the same litters are not significantly different by SAS (2006).

Table 2. Results of the application of plain molasses gel and plain crushed maize to caged roof rats in free-choice feeding tests. Average is followed by \pm S. D., and range in (parentheses).

No. of individuals	Average body weight (g)	Average daily consumption of plain crushed maize (g) (1)	Average daily consumption of Plain molasses gel (g)		Accept-ability (%)	Molasses gel as % of crushed maize (2/1%)
			Total	90% of consumed molasses gel (2)		
8	203.75 \pm 25.04 (170-240)	12.06 \pm 6.19 A (7.92-26.86)	6.58 \pm 2.52 (3.77-9.99)	5.92 B	32.93	49.10

The vertical columns marked with the same litters are not significantly different by SAS (2006).

Table 3. Results of the application of 0.5% zinc phosphide/molasses gel and plain crushed maize to caged roof rats in free-choice feeding tests. Average is followed by \pm S. D., and the range in (parentheses).

No. of individuals.	Mean body weight (BW) (g).	Average daily consumption of plain crushed maize (g) (1)	Average daily consumption of zinc phosphide/molasses gel (g)		Average amount of daily ingested zinc phosphide (mg)	Average daily ingested zinc phosphide in relation to BW and LD ₅₀			Acceptability (%)	Mortalities		Toxic bait as percent of crushed maize (2/1%)
			Total	90% of consumption (2)		mg/kg	LD ₅₀	Expressed as LD ₅₀		No.	(%)	
8	177.5 \pm 34.54 (130-230)	7.48 \pm 5.67B (0.95-14.21)	4.71 \pm 1.14 (3.44 - 6.19)	4.24CB	21.2	119.4	21.3	5.61	36.17	4	50	56.67

The vertical columns marked with the same litters are not significantly different by SAS(2006).

Table 4. Results of the application of plain crushed maize and 0.5% zinc phosphide/crushed maize bait to caged roof rats in a free-choice test. Average is followed by \pm S.D., and range (in parentheses).

No.	Mean body weight (g)	Average individual daily consumption (g)		Acceptability (%)	Mortalities	
		Untreated crushed maize	Zinc phosphide/crushed maize		No.	%
6	188.33 \pm 37.64 (140-240)	3.42 \pm 2.88CB (0.02-6.69)	0.82 \pm 0.54C (0.40 -1.65)	19.34	2	33.33

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اختبار كفاءة خليط غذائي-عالق من جيلاتين العسل الأسود وفوسفيد الزنك في مقاومة جرد الاسطح ومقارنته مع أسلوب تقليدي

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أجريت هذه الدراسة كمحاولة للتغلب على مشكلة النفور عن الطعوم السامة بواسطة الجردان بعد تناولهم جرعة غير مميتة من السموم. وتقوم فكرة الدراسة على خلط المادة السامة المستخدمة فى المقاومة مع مادة جيلاتينية وجعلها تعلق بفراء الجردان. وعندما تقوم هذه الجردان بتنظيف فرائها بواسطة اللعق، فإنها تبتلع المادة السامة وتموت. ولقد تم إجراء تجارب معملية للتغذية الاختيارية والقسرية لتقييم كفاءة الجيلاتين السام عندما يقدم للجردان بواسطة جهاز بسيط، وتمت مقارنة كفاءة هذه الطريقة بطريقة تقليدية للمقاومة.

ولقد أوضحت نتائج التجارب الاغذائية القسرية أن متوسط الكميات اليومية التى يقوم الجرد باستهلاكها من جيلاتين العسل الأسود النقى، وجيلاتين العسل الأسود المخلوط بفوسفيد الزنك السام بلغت ٦,٦% و ٧,٥% من متوسط وزن جسمه، على التوالى. وبناء على ذلك، بلغ متوسط ما ابتلعه الجرد الواحد من مادة فوسفيد الزنك السامة ٦٨,٤مجم يوميا، وبلغ معدل وفيات الجردان ٧٥% على مدى يومين من ابتلاعها المادة السامة.

ولقد أوضحت نتائج التجارب الاغذائية الاختيارية أن متوسط الكميات اليومية من جيلاتين العسل الأسود النقى التى قام الجرد باستهلاكها بلغت ٤٨,٧% من كمية ما استهلكه من الذرة المجروشة، وبلغ معدل الاستساغة ٣٢,٩%. ولقد كان متوسط الاستهلاك اليومي من الجيلاتين السام ٥٦% من كمية ما استهلكه الفرد من الذرة المجروشة. وبلغ متوسط ما ابتلعه الفرد من مادة فوسفيد الزنك ٢١مجم فى اليوم. ولقد كانت هذه الكمية كافية لقتل ٥٠% من جردان التجربة. أما معدل استساغة الجيلاتين السام، بالمقارنة بالذرة المجروشة، فقد بلغ ٣٦,٢%. ولقد كان متوسط الاستهلاك اليومي من الذرة المخلوطة بفوسفيد الزنك أقل من مثيله من الذرة المجروشة النقية، وكان معدل الاستساغة والوفيات ١٩,٣% و ٣٣,٣%، على التوالى.

ويتبين من نتائج هذه الدراسة أن معدل استساغة الجيلاتين السام كان حوالى ضعف معدل استساغة الذرة المجروشة السامة، وذلك مقابل الذرة المجروشة النقية، وأن معدل الوفيات بين الجردان المعرضة للجيلاتين السام كان أعلى من معدله بين الجردان المعرضة للذرة المجروشة السامة.