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Laboratory effects and efficacy of a Se-based rodenticide in controlling rodents in storage facilities

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Abstract

As resistance to anticoagulant-based rodenticides has been reported worldwide, we tested products with an active ingredient to which no resistance has been observed so far, which is environmentally safe and poses no threat of secondary poisoning. The rodenticide tested is based on Se (0.1 % sodium selenite) and its mode of action on the replacement of the SH group of functionaly enzymes with the S-S group. Palatability of the Se-based product was tested in laboratory using 20 individuals (10 males, 10 females) of each test species, i.e. the Swiss mouse strain and Wistar rat strain. The rats were fed on 10 g and mice on 4 g daily diets, and the symptoms of poisoning and mortality were monitored for 28 days. Mortality was recorded from day 6 to day 20, while the respective mortality period for mice was from day 9 to 14. The males of both rodent species died earlier than females. The results show that total product intake (around 100-150 g by rats and 60-80 g by mice) equalled approximately that of the reference active ingredients (vitamin D3 and bromadiolone). The fact that symptoms of intoxication are not visible before death occurs is a product advantage as rodents tend to discontinue consuming a bait once individuals in their community start dying.

As part of the efficacy testing, we compared effects of the Se-based product in granular and paraffin briquette formulations, vitamin D3 granules and paraffin briquettes, and a bromadiolone-based product against gray rat (*Rattus norvegicus*) and house mouse (*Mus musculus*) in storage facilities. The investigation complied with the relevant OEPP method (1998).

The new Se-based products achieved good efficacy of 91.10 % and 87.50 % in controlling rat, and 97.60 % and 98.40 % in controlling mouse, compared to the D3 products: 93.00 % and 90.30 % (rat), and 98.60 % and 98.20 % (mouse), and bromadiolone: 93.80 % and 90.70 % (rat), and 92.86 % and 97.20 % (mouse).

Key works: rodenticide, storage facilities, control rodents.

Introduction

Integrated pest management (IPM) is a complex approach to agricultural operations involving, among other methods, the use of natural products in preventing damage. The system is designed to satisfy both the manufacturing and environmental interestes (Kogan, 1998).

Several methods are currently available in agricultural storage facilities for controlling or reducing potential damage by rodents, but IPM

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programmes are still insufficiently developed (Haines, 2000, Spragins, 2006). Anti-coagulant products have been used to protect stored agricultural products for many years now, but resistance to them, especially to the first generation anti-coagulants, and increasingly to bromadiolone, has been reported worldwide. A number of studies and publications have tackled this problem across the globe. The Rodent Resistance Action Committee (RRAC) has been set up to monitor the issue. Rodents are known to be able also to develop resistance to some newly-designed anti-coagualants, as well as cross-resistance to old and new compounds (Lund, 1984., Greaves, 1995., Myllymaki, 1995., Thijssen, 1995.).

We therefore tested products that contain an active ingredient to which no resistance has been observed and which can be applied in cases of altered susceptibility to other rodenticides currently in use, while being environmentaly safe and not causing secondary poisoning.

A rodenticide based on Se (0.1 % sodium selenite), with the mode of action based on the replacement of the SH group of functional enzymes with the S-S groups, was tested.

Products based on vitamin D3 (calciferol or cholecalciferol) were also tested, their mode of action being the mobilization of calcium from bones and tissues, and calcification in blood vessels, kidneys, liver and heart, which ultimately results in heart failure.

Materials and methods

Palatability and effectiveness of products based on Se was tested on 20 laboratory Swiss mice (10 males and 10 females) and 20 laboratory Wistar rats (10 males and 10 females). The mice were divided up into 4 cages, 5 animals in each, and the rats into 4 groups of 3 animals and 2 groups of 4 animals per cage. Males were separated from females and all animals had continual access to water.

After 7 days of accomodation to laboratory conditions, treatment began with the product EKOSEL-C (KH) granules (0.1 % Na selenite). Rats were fed on 10 g daily doses of product per animal, and mice on 4 g per animal. Palatability (consumption) was monitored daily and symptoms of poisoning and rates of mortality recorded.

Six products manufactured by the company A.D. "Ciklonizacija", Novi Sad, Serbia, were tested against *Rattus rattus* and *Mus musculus* in the biological efficacy trials: EKOSEL-C(KH) granules (0.1 % Na selenite); EKOSEL-C(KH) paraffinized block (0.1 % Na selenite); EKOSTOP-D3 granules (0.075 % cholecalciferol); EKOSTOP-D3 paraffinized briquettes (0.075 % cholecalciferol); MAMAK B (KH) granules (0.005 % bromadiolone); MAMAK B (KH) paraffinized block (0.005% bromadiolone).

Product efficacy was tested in the feed mixing facility of the Institute of Animal Husbandry in Belgrade, the storage room of the Old People's Home "Be•anijska Kosa", Belgrade, and the warehouse of the Edible Oil Factory "Evit", Vrbas.

The feed mixing and storage room of the Institute of Animal Husbantry is a hall sized 20 x 30 m that contains a feed mixing machine with accessory electrical wiring, and sacks of feed lifted up on palettes.

The storage room of the Old People's Home "Be•anijska Kosa" is sized 20 x 25 m with palettes supporting sacks with foodstuffs such as flour, potatoes, sugar, various vegetables, oil, etc. A unit for storage and preparation of meat and fish with a tiled sanitary block is included.

The warehouse of the Edible Oil Factory "Evit" in Vrbas is sized 15 x 70 m and contains rows of palettes with packed products.

Mus musculus was found in the Institute's feed mixer and storage facility, and *Rattus rattus* in the storage room of the Old People's Home and warehouse of the Edible Oil Factory.

The experiments complied with the PP 1/ 114(2) method (OEPP/EPPO, 1999). Rodent abundance was assessed using the C-30 method (World Health Organization) or the transect method (EPPO, 1990; EPPO, 1992) at the beginning and 10 days after the beginning of

experiment. Placebo bait was laid at 10 spots in each facility over a period of 5 days.

Test baits were laid on plates in portions of 15-25 g for mice and 80-100 g for rats at 2-4 m intervals directly into active holes where rodent activity or damage had been observed previously (Figure 1), around electrical wiring and along rodent paths (underneath palettes).

Daily bait intakes were monitored for ten days and plates replenished as needed. Rodent abundance was assessed based on the highest and lowest daily bait intakes, devided by their daily requirements. Rodent presence was monitored over the next 20 days.

Data on palatability and biological effectiveness of products under laboratory conditions and rodenticide efficacy against rodents in storage facilities were calculated according to Abbott's formula (1925).

Results

Data presented in Figure 2 shows the palatability of Se-based products in laboratory.

Table 1 shows biological effectiveness of Se-based products under laboratory conditions against *Mus musculus* and *Rattus rattus*.

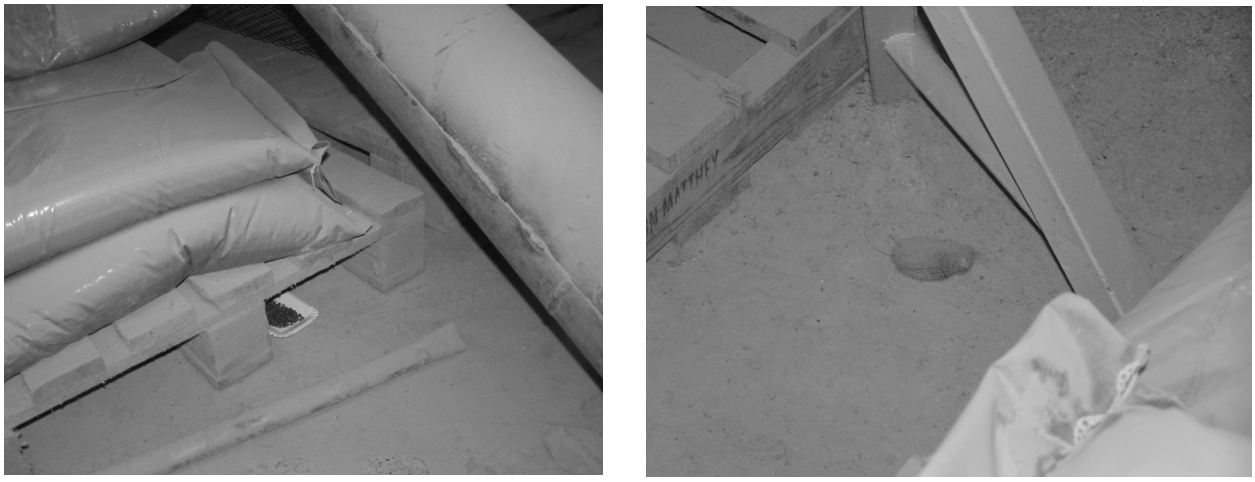

Figure 1. Bait laid and dead *Mus musculus* in the feed mixing facility of the Institute of Animal Husbandry.

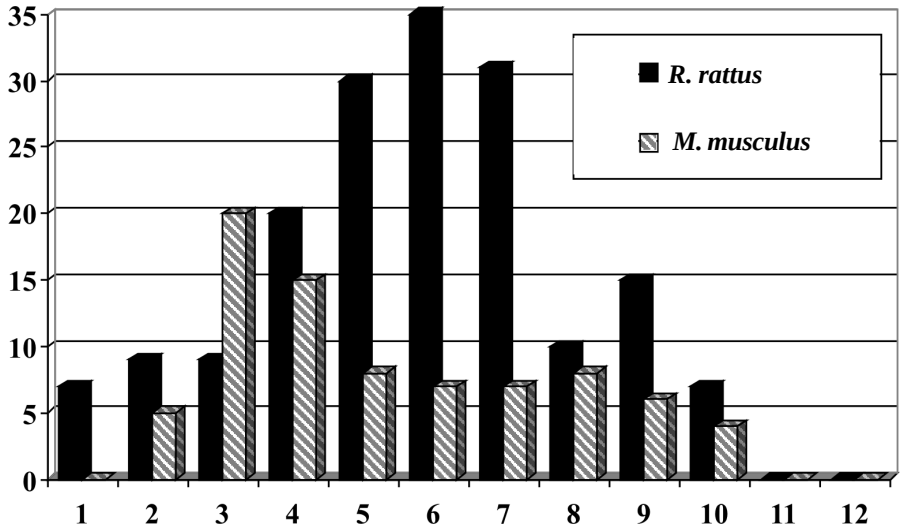

Figure 2. Palatability of the Se-based product.

Table 1. Biological effectiveness of Se-based product in laboratory conditions.

Trial days	Species			
	Rattus rattus		*Mus musculus*	
	Male	Female	Male	Female
1	-	-	-	-
2	-	-	-	-
3	-	-	-	-
4	-		-	-
5	-	-	-	-
6	2	-	-	-
7	1	2	-	-
8	1	-	-	-
9	-	2	1	1
10	2	1	3	1
11	1	3	-	-
12	-	-	1	2
13	2	1	1	3
14	1	1	4	3
15	-	-	-	-
16	-	-	-	-
17	-	-	-	-
18	-	-	-	-
19	-	-	-	-
20	-	-	-	-

Table 2 shows the efficacy of the Se-based products EKOSEL-C(KH) granule and EKOSEL-C(KH) paraffin block, cholecalciferol-based products (vitamin D3) EKOSTOP-D3 granule and EKOSTOP-D3 paraffinized briquettes, and bromadiolone-based products MAMAK B (KH) granule and MAMAK B (KH) paraffin block, all applied against *Mus musculus* and *Rattus rattus* in storage facilities.

Discussion

Experimental results indicate that the test products intake by laboratory animals (approximately 150-180 g by rats and 60-80 g by mice) was similar to the other registered products based on bromadiolone and vitamin D.

Rat mortality in the preliminary trial was first recorded on the 6th day after treatment, and last on the 20th day. Mouse mortality began 9 days and ended 14 days after treatment. Different mortality rates were found between males and females, both for rats and mice, i.e. males were dying sooner than females (6-14 days after application for rats and 9-12 days for mice).

The Se-based products have the advantage of not causing visible symptoms of intoxication until the animal is dead, which is important as rodents are known to stop consuming a product after noticing symptoms and mortality in their population.

As the results of laboratory testing were positive, we investigated the biological efficacy of the product formulations based on Se, comparing the data to products based on cholecalciferol (vitamin D3) and bromadiolone against rats (*Rattus spp.*) and mice (*Mus musculus*) in several storage facilities of agricultural products. The results show a very good efficacy of the Se-based product in controlling rat (91.10 % and 87.50 %) and

mouse (97.60 % and 98.40 %), compared to the products based on vitamin D3 (93.00 % and 90.30 % against rats; 98.60 % and 98.20 % against mice) and bromadiolone (93.8 % and 90.7 % against rats; 92.86 % and 91.9 % against mice).

No data is available in literature on Se being used as a rodenticide. However, this investigation shows that very good efficacy of such products can be achieved. Our results of the efficacy tests of cholecalciferol- (vitamin D3) and bromadiolone-based products in controlling *Mus musculus* and *Rattus rattus* agree with reports by other authors (Rowe, F.P. et al., 1981; Parshad et al., 1987; Brooks and Rowe, 1987; Quy et al., 1999; Vukša et al. 2002).

Selenium is an active substance used in human and veterinary medicine as a vitamin and, in its biologically active form, it is a micronutrient important for immune responses. However, as doses much higher than the recommended therapeutical ones are used for this purpose, and acute toxicity, toxicological and ecotoxicological data support it (Anonimous, 1993), sodium selenite as an active ingredient has been clasiffied into poison group II in Serbia and approved to be used as a rodenticide. Se-based products have been classified into poison group III as the concentration of sodium selenite as an active ingredient in them is only 0.10 %.

Good efficacy, favourable ecological properties and the fact that there have been no known cases of resistance make the Se-based products recommendable for use in controlling rodents in storage facilities.

Acknowledgement

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Table 2. Bait intake (g), rodent abundance and rodenticide efficacy.

Product	Species	Abundance		Efficacy (%)
		Beginning	End	
MAMAK B (KH) granules	*R. rattus*	32	2	93.80
	M. musculus	14	1	92.86
MAMAK B (KH) paraffin block	*R. rattus*	43	4	90.70
	M. musculus	11	2	97.20
EKOSTOP-D3 granules	*R. rattus*	57	4	93.00
	M. musculus	10	1	98.60
EKOSTOP-D3 paraffinized briquettes	*R. rattus*	52	5	90.30
	M. musculus	7	1	98.20
EKOSEL-C granules	*R. rattus*	45	4	91.10
	M. musculus	14	2	97.60
EKOSEL-C paraffin block	*R. rattus*	48	6	87.50
	M. musculus	11	1	98.40

References

Abbott, W.S., 1925. A method of computing the effectiveness of an isecticide. J. Econ. Entomol. 18,265-267.

Anonymous, 1993. Sodium selenite. Offical Publications of the European Communities, Luxembourg, International Programme on Chemical Safety (IPCS), World Health Organization, Switzerland.

Brooks, E.J., Rowe, P.F., 1987. Commensal rodent control. World Health Organization, WHO/VBC/87.949.

EPPO, 1990. Guidline on design and analysis of efficacy evaluation trials. No.152, EPPO Bull., 20, 551-579.

EPPO, 1992. Guide for the efficacy evaluation of rodenticides, No.169, EPPO Bull., 22, 181-202.

EPPO, 1999. Guideline for the efficacy evaluation of rodenticides: Field tests against synanthropic rodents (*Mus musculus, Rattus norvegicus* and *R. rattus*) – PP 1/114(2), in EPPO 1999. Guidelines for the efficacy evaluation of Plant Protection Products. Rodenticides, 1, European and Mediterranean Plant Protection Organization, Paris, pp. 83-144.

Greaves, J.H., 1995. Managing resistance to anticoagulant rodenticides: An appraisal. Pestic. Sci. 43, 72-82.

Haines, C.P., 2000. IPM for food storage in developing countries: 20th Century aspirations for the 21st Century. Crop Protection 19, 825-830.

Kogan, M., 1998. Integrated Pest Management. Historical Perspectives and Contemporary Developments. Annual Review of Entomology 43, 243-270.

Lund, M., 1984. Resistance to the second generation anticoagulant rodenticides. In: Proceedings of Eleventh Vertebrate Pest Conference. Sacramento, California (Ed. by D.O.Clarck), pp. 89-94.

Myllymaki, A., 1995. Anticoagulant resustance in Europe: Appraisal of the data from 1992 EPPO questionnaire. Prestic. Sci., 43, 69-72.

Parshad, V.R., Ahmad, N., Chopra, G., 1987. Deterioration of poultry farm environment by commensal rodents and their control. International Biodeterioration 23, 29-46.

Quy, R.J., Cowan, D.P., Prescott, C.V., Gill, E.J., Kerins, G.M., Dunsfort, G., Jones, A., MacNicol, A.D., 1995. Control of a Population of Norway Rats Resistant to Anticoagulant Rodenticides. Pestic. Sci., 45, 247-256.

Rowe, F.P., Plant, C.J., Bradfield, A., 1981. Trials of the anticoagulant rodenticides bromadiolone and difenacoum against the house mouse (*Mus musculus* L.). Journal of Hygiene, London 81, 171-177.

Spragins, C.W., 2006. Advances in IPM Rodent Control in Agriculture. Rockwell Laboratories Ltd., Minneapolis, MN, USA.

Thijssen, H.H.W., 1995. Warfarin-based rodenticides: Mode of action and mechanism of resistance. Pestic. Sci. 43, 73-78.

Vukša, M., Đedovic S., Draganic, M i Dragojlovic, M. 2002. Ispitivanje palatabilnosti i efikasnosti mamaka DETRIN-KH (formulacije GB i BB) na bazi vitamina D3 u laboratorijskim uslovima i komunalnoj higijeni, Zbornik radova XIII Savetovanja DDD u zaštiti zivotne sredine (sa međunarodnim uèešcem) , Kikinda, 179-189.