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# Enhancement of Mammalian Safety by Incorporation of Antimony Potassium Tartrate in Zinc Phosphide Baits

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Antimony potassium tartrate ($C_4H_4KO_7Sb\frac{1}{2}H_2O$) (APT) popularly known as tartar emetic is widely utilized in the treatment of various parasitic infections such as leishmaniasis, schistomasis, ascariasis, trypanosomasis and bilharziasis in various animal species (ALBERT 1968; GRADWOHL 1956; STECHER 1968). It is also used as an expectorant for cattle, horses, sheep, goats, swine and dogs. As an insecticide, it has been found to be effective against thrips and has been recommended as a spray on onions (EWART et al. 1944), gladioli (JOHNSON 1940) and citrus trees (BOYCE and PERSING 1939). Further, its utility as an emetic in treating cases of accidental poisoning of the human beings is well documented (GRADWOHL 1956).

Considering the fact that rats cannot vomit, APT has been incorporated in the rodenticidal baits to enhance the mammalian safety and to protect the non-target species. It has been used at different concentration varying from 1% (EMLEN and STOKES 1947) to 27.3% for the same purpose (PINGALE et al. 1967, FITZWATER and I.PRAKASH 1973; and SCHOOF 1970). However, they have also reported that acceptability to the rats of the poison baits containing APT was very much lowered. Hence attempts were made in this laboratory to find out a suitable or optimum concentration of APT that could be incorporated in the poison baits, which will not affect the toxicity or palatability of the baits, but which will induce vomitting when the poison bait is ingested accidentally by the non-target species. Further, keeping in view the high $LD_{50}$ value of APT to many other mammals and its low requirement to kill animals like rats, mice and rabbits (SPECTOR 1955; VENUGOPAL and LUCKY, 1978), the possibility of utilising APT alone as a rodenticide has also been explored in this study.

## MATERIALS AND METHODS

Animals: Albino rats (R.norvegicus) of CFT-Wistar strain maintained in the Animal House at this Institute and roof rats (R. rattus) trapped from different locales which were maintained on stock diet and water ad libitum in the conditioning cages were used. The body weight of the albino rats ranged from 170-250 g and that of roof rats from 70-120 g. For each concentration 8-10 animals were used.

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Materials and their preparation: Antimony potassium tartrate obtained from Sarabhai M.Chemicals, India and Zinc Phosphide from M/S Swadeshi Chemicals Ltd. Bombay were used. Antimony potassium tartrate dissolved in water was used for forced feeding trials. In ad-libitum trials APT was thoroughly mixed with 1 and 2% zinc phosphide bait, standard bait (KRISHNAKUMARI et al. 1963) being the carrier to get the required concentrations (Table 1).

Test procedure

Ad libitum trials: (Wistars and roof rats): Individually caged rats of known weight and sex were fed daily with the test bait (20 g) containing different concentrations of antimony potassium tartrate for 7 days. Zinc phosphide alone and along with antimony potassium tartrate in bait was presented to rats for one night only. Water was always available ad libitum. Daily records on bait consumption, symptoms, mortality and death time of each rat were maintained. Survivors, maintained on stock diet, were observed for a period of one month.

Forced feeding trials (Wistar only): Groups of ten rats each, were fed antimony potassium tartrate dissolved in water with the help of stomach tube. The dosage administered were 0, 300, 400, 532 and 707 mg/kg b.w. The rats were given food and water after 24 hours of forced feeding and they were observed for symptoms and mortality for 7 days. The survivors, maintained on stock diet, were kept under observation for a further period of 3 weeks.

## RESULTS

Tests on Albino rats: Trials with zinc phosphide containing APT:

Zinc phosphide alone at 1.0 and 2.0% resulted in 100% mortality of test rats within 18 hours of feeding and the average bait consumption was 1.3 and 1.6 gms, respectively (Table 1).

Although the addition of 1 and 2% APT to zinc phosphide (1%) reduced the bait intake slightly, addition of APT at lower concentrations (0.5 or 0.25%) did not affect the mortality or acceptability of bait when compared to zinc phosphide alone (Table 1).

Test on roof rats

Since zinc phosphide baits (1 and 2%) containing 0.25% APT showed promising results in the tests on albino rats, the same combination was further evaluated against roof rats. The results obtained were similar to that of albino rats. Addition of 0.25% APT did not alter the toxicity or palatability of 1 and 2% zinc phosphide baits (Table 1).

Trials with Antimony potassium tartrate (Wistar rats only):

Forced feeding trials: The administration of four different doses

TABLE 1

Ad libitum trials of the zinc phosphide bait containing Antimony Potassium tartrate on albino and roof rats

| Chemical | Concentration in bait (%) | Average body weight (g) | No. of rats Tested | No. of rats Accepting the bait | No. of rats Dead | Average poison bait intake (g) | Average a.i. intake (mg/kg) | Average death time (hrs) |
|---|---|---|---|---|---|---|---|---|
| R. norvegicus | | | | | | | | |
| Zinc phosphide | 1.0 | 200 | 8 | 6 | 6 | 1.3 | 89.5(33.8-180) | 18.20(12-25) |
| | 2.0 | 218 | 8 | 8 | 8 | 1.6 | 163(73.0-252) | 16.0(8-20) |
| Zinc Phosphide + APT | 1.0+2.0 | 203 | 8 | 4 | 4 | 1.2 | 42.4+84.8 | 28.0(16-34) |
| | 1.0+1.0 | 183 | 8 | 5 | 5 | 1.0 | 54.5+54.5 | 20.30(16-34) |
| | 1.0+0.5 | 192 | 8 | 7 | 7 | 1.4 | 52.2+26.1 | 23.15(16-34) |
| | 1.0+0.25 | 190 | 8 | 7 | 7 | 1.2 | 64.9+16.2 | 23.15(16-34) |
| | 2.0+0.25 | 186 | 8 | 7 | 7 | 1.2 | 147.0+18.3 | 18.0(12-28) |
| R. rattus | | | | | | | | |
| Zinc phosphide | 1.0 | 112 | 8 | 8 | 8 | 1.3 | 116.2(67-166.6) | 10.0(8-12) |
| | 2.0 | 102 | 8 | 8 | 8 | 1.4 | 274.5(185-315) | 8.0(5.3-16) |
| Zinc Phosphide + APT | 1.0+0.25 | 105 | 8 | 8 | 8 | 0.9 | 85.3+21.3 | 19.0(8-32) |
| | 2.0+0.25 | 113 | 8 | 8 | 8 | 1.0 | 176+22.0 | 18.0(6-23) |

of APT viz., 300, 400, 534 and 707 mg/kg b.w. resulted in 20, 50, 70 and 100% mortality of test rats respectively (Table 2). Generally the rats succumbed within 44 hours of intubation although the death time ranged from 2½-68 hours. As the dosage increased, the average death time decreased to 23 hours from 44 hours. The rats which succumbed to APT did not manifest any toxic symptoms and they remained calm and quiet (except for a short period of convulsions which preceded the death). The $LD_{50}$ value obtained by Finney's method (1971) was 494 mg/kg b.w. with a fiducial limit of 229-1066 mg/kg b.w.

Ad libitum trials: None of the rats succumbed to antimony potassium tartrate fed at various concentrations (0.25-20.0%) in diet for 7 days continuously (Table 3).

The average consumption of APT (active ingredient) ranged from 268-2116 mg/kg b.w. The rats accepted the bait daily when the bait contained lower concentration of APT. The average bait intake was 98.4, 90.0, 71.4, 35.0 and 23.6 gms respectively for 0.0, 0.25, 0.5, 1.0 and 2.0%. However, bait intake was less (1.0-1.5 gms) when its concentration was 5.0% and above.

## DISCUSSION

APT has been added to zinc phosphide bait at a ratio of 3:8 (= 27.3%) in order to reduce the danger to pets and increase safety to higher mammals (FITZWATER and I.PRAKASH 1973; PINGALE et al. 1967). However, this seems to be too high a ratio as our results indicate that if the level of APT is above 1.0% in bait, it greatly affects the palatability (Table 3). It was further observed that the roof rats could detect the presence of APT even at a low level of 0.25% (Table 1), since intake was slightly reduced as compared to controls. This observation was further corroborated by the results obtained by EMLEN and STOKES (1947) wherein they have reported that addition of 1% APT to zinc phosphide baits resulted in poor control as the acceptability of zinc phosphide baits was lowered. Hence, it is suggestive here that the optimum concentration of APT to be added along with zinc phosphide baits should be restricted to 0.25-0.5%.

GRADWOHL (1956) recommends 0.006 gm of APT in 25 ml of water (=0.024%) to induce vomitting in man and STECHER (1968) recommends 100-300 mg for dogs in cases of accidental poisoning. Hence the addition of APT at 0.25% level to zinc phosphide baits seems to be sufficient to cause vomitting in pets and human beings in cases of accidental poisoning. This concentration of APT in baits not only ensures mammalian safety but also retains the palatability without affecting the efficacy of the poison towards the target species.

As regards $LD_{50}$ of APT to rats, VENUGOPAL and LUCKY (1978) have reported that it is 115 mg/kg b.w. However, the value obtained in our experiment was 494 mg/kg b.w. This difference could be due to either the age, species, sex, vehicle or the route of

TABLE 2

Forced feeding trials of Antimony potassium tartrate against R. norvegicus (albino)

| Dosage mg/kg b.w. | Average body weight (g) | No. tested/ No. dead | Death time in hrs |
|---|---|---|---|
| 0 | 203 | 10/0 | 0 |
| 300 | 198 | 10/2 | 44 (44-44) |
| 400 | 204 | 10/5 | 36.6 (19-68) |
| 532 | 198 | 10/7 | 23.0 (2.5-44) |
| 707 | 203 | 10/10 | 27.2 (19-44) |

$LD_{50}$: 494 mg/kg b.w.
Fiducial limits (95%): 229-1066 mg/kg b.w.

administration (BOYD, 1972). SPECTOR (1955) and STECHER (1968) have reported that the $LD_{50}$ value of APT to mice ranged from 599-666 mg/kg b.w. This may be an indication that the rats are more susceptible to APT than mice.

In the ad libitum trials despite the ingestion of 2521 mg/kg b.w. of APT, no mortality was observed which may due to the fact that $Sb^{124}$ labelled potassium antimonyl tartrate is excreted more in faeces than in urine indicating poor alimentary absorption (WEITZ and OBER 1965). In the forced feeding trials, the mortalities obtained may be due to the absorption of antimony in the ionized form in the animal system ($C_4H_4KO_7Sb\frac{1}{2}H_2O \longrightarrow K^+ + Sb^{+++} + C_4H_4O_7$).

It is also documented that trivalent antimony compounds are many times more lethal than pentavalent derivatives (GLEASON, GOSSILIN and HODGE 1957). Further, the symptoms observed in rats fed APT, such as animals remaining calm, huddling together and a short period of convulsion preceding death resembles those due to metallic poison.

Considering the high $LD_{50}$ value to non-rodent species, and it being an emetic to higher mammals, APT can be an 'Ideal' rodenticide if the palatability of the baits containing APT can be improved so that the rats consume the lethal dose in a single feed.

TABLE 3

Ad libitum trials utilising Antimony Potassium tartrate alone in the bait on R.norvegicus (albino)

| Concentration in bait (%) | Average body weight (g) | No. of Rats | | | Average bait intake/rat (g) | Average a.i. intake (mg/kg b.w) | Average death time (hrs) |
|---|---|---|---|---|---|---|---|
| | | Tested | Accepting the bait | Dead | | | |
| 0 | 205 | 8 | 8 | 0 | 98.4 (77-118) | 0 | 0 |
| 0.25 | 210 | 8 | 8 | 0 | 90.0 (45-91) | 1072.2 (548-1141) | 0 |
| 0.5 | 202 | 8 | 8 | 0 | 71.4 (55-75) | 1825.7 (1285-1994) | 0 |
| 1.0 | 201 | 8 | 7 | 0 | 35.0 (2.0-48) | 1625.6 (116-2232) | 0 |
| 2.0 | 224 | 8 | 5 | 0 | 23.6 (14-29) | 2116 (1152-2521) | 0 |
| 5.0 | 213 | 8 | 4 | 0 | 1.5 (1-2) | 267.8 (435-510) | 0 |
| 10.0 | 203 | 8 | 3 | 0 | 1.5 (1-2) | 490.7 (435-510) | 0 |
| 20.0 | 207 | 8 | 1 | 0 | 1.0 | 952.0 | 0 |

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