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Inefficacy of Cement and Cellulose-Based Baits as Rodenticides against Synanthropic Rodents in Subtropical Climatic Zone

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Abstract: Effective management of synanthropic rodent pests using natural, eco-friendly materials instead of chemical rodenticides represents a vital advancement in integrated pest management strategies. The present study evaluated the potential of cement- and cellulose-based baits as rodenticides under both controlled laboratory and field conditions. Various bait formulations were tested, including chapatti pieces coated with cement, wheat flour mixed with cement in varying proportions (4:1, 2:1, 1:1, and 1:2), only cement, and cereal-based baits containing 25% and 50% cellulose powder. These were offered to *Bandicota bengalensis* and *Rattus rattus* in no-choice and bi-choice feeding trials. Despite significant bait consumption, the rats exhibited no mortality, maintained normal activity levels, and showed no deviation in their water intake. Residues of both cement and cellulose were evident in their feces. Field trials further reinforced these findings. Placement of cement-coated chapatti pieces near active burrows of *B. bengalensis* in sugarcane fields failed to produce any reduction in burrow activity or signs of toxicity, despite evident bait consumption. This study provides conclusive evidence that cement- and cellulose-based baits are ineffective as rodenticides. These findings underscore the critical need for continued research to explore and develop effective, environmentally safe alternatives to chemical rodenticides for sustainable rodent pest management.

Keywords: Cellulose, Cement, Rodenticide, Rodents, Toxicity

Rodents represent the most diverse mammalian order, Rodentia (Burgin et al., 2018) and majority play essential ecological roles, a small but highly impactful proportion (7–10%) are notorious agricultural and infrastructural pests (Hernandez et al., 2021). These inflict substantial economic losses by ravaging field crops and stored grains (Legese and Bekele 2023). More alarmingly, rodents serve as primary reservoirs of zoonotic parasites, transmitting serious diseases directly or vector-mediated (Singla et al., 2016, Brar et al., 2021, Mandla et al., 2022, Brar et al., 2024). Effectively controlling rodent populations necessitates an integrated pest management strategy combining both lethal and non-lethal approaches. Key control measures include environmental sanitation, rodent-proofing, trapping, and the strategic use of rodenticides (Stuart et al., 2025). Zinc phosphide remains the most widely used acute rodenticide worldwide due to its high efficacy, affordability, and relatively favourable safety profile (Eason et al., 2013). However, it presents significant challenges, including bait aversion and the survival of sub-lethally poisoned rodents, leading to control failures (Horak et al., 2018). Chronic anticoagulant rodenticides such as warfarin, coumatetralyl, bromadiolone, and brodifacoum are effective but pose serious risks of resistance development and secondary toxicity (Hernandez-Moreno et al., 2013, Runge et al., 2013, Garg et al., 2017, Sharma et al., 2024). Given these limitations, there is an urgent need for alternative rodent control strategies that are cost-effective, environmentally sustainable, resistance-free, and safer for non-target species. Developing such alternatives is critical for ensuring long-term success in rodent pest management.

Cellulose, a fundamental component of plant cells, exhibits a mode of action distinct from conventional chemical rodenticides (Jokic et al., 2014). Research has demonstrated that cellulose-based corn cob baits possess potent rodenticidal properties (Issa et al., 2021). The groundbreaking ecologically friendly rodenticide derived from powdered maize cobs (40–45% cellulose) achieved an impressive 91.66% efficacy in controlling *Mus musculus* populations (Jokic et al., 2006). Similarly, the cellulose-based product *Natromouse* was proven highly effective, reducing rodent populations by 86–98% in alfalfa and wheat fields (Jokic et al., 2007). Cement, a fine gray or white powder primarily composed of cement kiln dust, is a critical component of concrete and mortar. Its composition includes calcium, silicon, aluminum, ferric, and magnesium oxides, with trace elements such as potassium sulfate, sodium sulfate, chromium, and nickel (Akinola et al., 2008). The content of hazardous metals in cement particles varies according to the raw material used. Heavy metals, including cadmium (Cd), lead (Pb), chromium (Cr), cobalt (Co), Nickel (Ni), Manganese (Mn), Iron (Fe) and mercury (Hg), present in high amounts in cement dust particles, are known to be harmful even in small doses (Ogunbileje et al., 2013). Many of these components exhibit mortality and significant occupational and long-term health hazards to humans and animals (Donato et al., 2016, Owonikoko et al., 2021, Paithankar et al., 2021). Chemicals present in cement also cause allergy and complications related to the respiratory system in workers exposed to cement (Rahmani et al., 2018). The lethal action of cement- and cellulose-based rodenticidal baits stems from their ability to induce rapid dehydration, severe blood volume reduction, tissue necrosis, cardiac arrest, and eventual death (Jokic et al., 2006). These compelling findings have fueled growing scientific interest in evaluating their effectiveness against rodents. This study assessed the potential of cement- and cellulose-based baits as rodenticides targeting synanthropic rodent species, *Bandicota bengalensis* and *Rattus rattus*, that have significant economic and health importance, being agricultural pests and reservoirs of pathogens.

MATERIAL AND METHODS

The lesser bandicoot rat, B. bengalensis, and house rat, *R. rattus,* were live-trapped from agricultural fields, fish markets, and poultry farms in Ludhiana, India, which has a subtropical climate. In the laboratory, the captured rats were housed individually in cages and acclimatized for 15 to 20 days before the commencement of experiments. During this period, food and water were provided *ad libitum*. The diet consisted of a standardized bait mixture prepared using cracked wheat, powdered sugar, and peanut oil (WSO bait) in the ratio of 96:2:2. Following acclimatization, healthy adult rats of both sexes were weighed and used for further studies. Cement and cellulose were evaluated for their potential as rodenticides by assessing the acceptance and toxicity of treated baits through no-choice and bi-choice laboratory feeding trials. Individually housed rats were randomly assigned to groups, with five rats per group. Depending on the experimental setup, each cage was equipped with either one or two feeders along with a water dish.

In the first experiment, a total of seven groups of rats were used. Two groups were offered cement-coated chapatti pieces, one under no-choice conditions and the other under bi-choice conditions. Four groups were provided with bait formulations consisting of a mixture of wheat flour and cement dust in varying ratios of 4:1, 2:1, 1:1, and 1:2 under no-choice conditions. The seventh group was exposed to cement dust alone, in a no-choice test. All groups were exposed to their respective bait formulations for five consecutive days. Fresh bait was supplied regularly, and the amount of bait consumed by each rat was recorded daily. Water was replenished daily, and water consumption was similarly monitored. Throughout the trial and post-treatment period, rats were closely observed for any clinical signs of toxicity, mortality, changes in fecal consistency and colour, and any behavioural abnormalities. The toxicity of each bait formulation was assessed based on bait consumption patterns, water intake, clinical observations, and mortality, if any.

In the second experiment, cement-coated chapatti pieces were placed near 20 active burrows of *B. bengalensis* located in sugarcane fields at Ludhiana for four consecutive days. The effectiveness of the bait was assessed by recording bait consumption and changes in burrow activity. Burrows that were closed one day in the evening and reopened the following day in the morning were considered active or live.

In the third experiment, *R. rattus* rats were divided into groups (n = 5 per group) and exposed to WSO bait formulations containing 25% and 50% cellulose powder in both no-choice and bi-choice feeding trials for eight consecutive days. Water was provided *ad libitum* throughout the trial. Bait consumption was measured daily, replenished as needed, and expressed as g/100g body weight (bwt). Rats were monitored for mortality during the treatment period and for up to one month post-treatment. Additionally, daily observations were made to record clinical symptoms, mortality, fecal consistency and colour, and any behavioural abnormalities.

Statistical analysis: The results were expressed as mean ± standard deviation (SD), and differences were considered statistically significant at $P<0.05$ employing SPSS Software version 30.0.

RESULTS AND DISCUSSION

The cement-coated chapatti pieces, baits containing different proportions of wheat flour and cement, and cement alone exhibited no toxic effects on rats. The highest cement consumption (g/100g bwt) was in bait containing wheat flour and cement in a 1:2 ratio (28.43), followed by cement-coated chapatti pieces in the no-choice tests. The lowest consumption was observed for cement-coated chapatti pieces (4.15 g/100g bwt) in the bi-choice test and for cement alone (4.55 g/100g bwt) in the no-choice test. In other bait formulations containing wheat flour and cement at ratios of 1:1, 2:1, and 4:1 in no-choice, the cement consumption was 6.73, 5.40, and 5.64 g/100g bwt, respectively (Table 1). No mortality occurred during or after the treatments, and all rats remained active and healthy without any signs of abnormal behaviour.

The highest average daily water consumption was in rats fed on wheat flour: cement (1:2) bait (17.98 ml), followed by those offered only cement in a no-choice. In contrast, the lowest water intake was observed in rats fed cement-coated chapatti pieces during the no-choice trial (8.66 ml). These results suggest that there was no consistent or direct relationship between cement content in the bait and water consumption by rats.

Field application of cement-coated chapatti pieces near the active burrows of *B. bengalensis* in sugarcane fields did not yield significant control effects. One week after treatment, 18 out of 20 burrows (90%) remained active (Table 2), indicating that cement-coated chapatti pieces were non-toxic and ineffective for rodent control under field conditions. No direct studies are available in the literature that specifically evaluated the role of cement as a rodenticide. Akinola et al. (2008) exposed albino rats to cement dust for six weeks, resulting in pronounced pathological and toxic effects. They reported heavy metal bioaccumulation in the lungs and structural damage to vital organs such as the liver, heart, and kidneys, thereby highlighting the occupational hazards faced by cement factory workers. Similarly, Owonikoko et al. (2021) exposed male rats to cement dust for 14 and 28 days (5 hours daily) and reported clear signs of clinical toxicity, elevated serum heavy metal levels, reduced gastrointestinal motility, altered hematological parameters, poor movement coordination, abnormal posture, cephalic fur loss, and even mortality of one rat after two weeks of exposure. Contrary to these findings, the present study found no evidence of toxic effects of cement when ingested by rats, either in terms of mortality or any observable signs of abnormal behaviour, fur loss, or physical distress. This striking difference may be attributed either to the inherently non-toxic nature of cement when consumed orally or to the relatively short duration of exposure provided in the present study.

In no-choice feeding trials, rats consumed a significantly higher amount of cellulose when offered bait containing 50% cellulose for 8 days (37.73 g/100g bwt) compared to bait with 25% cellulose (18.23 g/100g bwt). Similar trend was observed in bi-choice tests, where cellulose intake over 8 days was greater with 50% cellulose bait (16.31 g/100g bwt) than with 25% cellulose bait (10.08±1.50 g/100g bwt). Overall, cellulose ingestion was significantly higher in no-choice tests than in bi-choice tests at both bait concentrations (Table 3). No mortality was observed in rats fed bait containing either 25% or 50% cellulose under both feeding conditions. Additionally, there were no noticeable changes in behaviour or adverse clinical signs in the treated rats.

The scientific literature on the effectiveness of cellulose-based rodenticides remains highly debated. Cellulose-based rodenticides have also proven effective against common voles (*Microtus arvalis*) in wheat and alfalfa crops (Jokic et al., 2010). Issa et al., (2021) observed 100% mortality of *Rattus norvegicus* in corn-based bait. However, Schmolz (2010), observed no mortality and very low palatability of commercial cellulose-based baits in both house mice (*Mus musculus*) and Norway rats (*R. norvegicus*). Present results also showed *no* mortality in rats fed cellulose baits. Based on the results of both laboratory and field tests, Zhelev et al. (2013) concluded that the cellulose-based rodenticide *'Eradirat'* is highly unpalatable to black rats (*R. rattus*). Furthermore, a 90-day subchronic toxicity study by Ong et al. (2020) found *no* systemic toxicity associated with the consumption of fibrillated cellulose. The study determined that the no observed adverse effect level for fibrillated cellulose was 2194.2 mg/kg/day for male and 2666.6 mg/kg/day for female Sprague Dawley rats. Experiments with traditional cellulose have demonstrated that rats can tolerate even higher levels, with no negative effects observed from a 30% cellulose diet, even after an extended 72-week period. This strongly underscores the safety and non-toxicity of cellulose in rodenticide applications.

In the present study, after baiting with various cemented and cellulose baits, fecal samples collected from the experimental cages showed traces of both cement and cellulose. This strongly indicates that the cement and cellulose were metabolized and subsequently excreted from the rats' bodies. The rats remained fully active and

Table 1. Effects of cement-coated chapatti pieces, wheat flour mixed with cement in different ratios, and only cement on *B. bengalensis* rats

Exposure	Treatment	Body weight (g) (n = 5 each)	Mean daily consumption (g/100g bwt)	Total consumption of treated bait (g/100g bwt)	Total consumption of cement (g/100g bwt)	Mean daily consumption of water (ml)	Total consumption of water (ml)
No-choice	Cement-coated chapatti pieces	336.00±37.28	7.94±1.20	39.68±6.02	11.90±1.81	8.66±1.44	43.32±7.19
Bi-choice	Cement-coated chapatti pieces	294.00±58.57	2.76±0.85-T 5.79±0.71-P	13.82±4.27	4.15±1.28	-	-
No-choice	Wheat flour: cement (4:1)	277.60±34.70	5.63±1.43	28.14±7.17	5.64±1.45	12.60±2.62	63.0±13.12
No-choice	Wheat flour: cement (2:1)	245.00±47.70	8.10±1.58	16.20±3.16	5.40±1.05	17.98±5.24	35.97±10.49
No-choice	Wheat flour: cement (1:1)	278.00±29.46	6.77±0.93	13.53±1.86	6.73±0.91	15.07±1.11	30.13 ±2.22
No-choice	Wheat flour: cement (1:2)	261.50±39.80	6.56±1.49	37.23±10.56	28.43±7.04	15.43±3.08	86.42±23.41
No-choice	Cement	257.00±24.04	1.15±0.35	4.55±1.34	4.55±1.34	16.40±2.55	65.65±10.25

T-Treated bait, P-Plain bait, No mortality was achieved in any treatment; All values are Mean±SE

Table 2. Evaluation of cement-coated chapatti pieces against rodents in sugarcane fields

Burrow no. *	Consumption (g) of treated bait out of the total 20 g kept daily				Mean daily consumption (g)	Total consumption in 4 days (g)
	Day 1	Day 2	Day 3	Day 4		
1	5.0	13.0	20.0	18.0	14.0	56.0
2	20.0	20.0	20.0	20.0	20.0	80.0
3	20.0	20.0	20.0	20.0	20.0	80.0
4	20.0	20.0	20.0	20.0	20.0	80.0
5	20.0	15.0	14.0	20.0	17.2	79.0
6	20.0	20.0	20.0	15.0	18.7	75.0
7	20.0	20.0	20.0	20.0	20.0	80.0
8	20.0	20.0	20.0	20.0	20.0	80.0
9	20.0	20.0	20.0	20.0	20.0	80.0
10	20.0	20.0	18.0	16.0	18.5	74.0
11	20.0	20.0	17.0	20.0	19.2	77.0
12	20.0	14.0	20.0	20.0	18.5	74.0
13	20.0	20.0	20.0	20.0	20.0	80.0
14	20.0	20.0	20.0	20.0	20.0	80.0
15	20.0	20.0	20.0	12.0	18.0	72.0
16	20.0	20.0	20.0	20.0	20.0	80.0
17	20.0	16.0	20.0	11.0	16.7	67.0
18	20.0	20.0	15.0	20.0	18.7	75.0
19	20.0	20.0	20.0	20.0	20.0	80.0
20	20.0	20.0	20.0	13.0	18.2	73.0
Mean	19.2	18.9	19.2	18.2	18.9	76.0

*18 burrows were still live after one week of treatment termination

Table 3. Effect of bait containing different concentrations of cellulose powder in *R. rattus*

Exposure	Cellulose concentration (%)	Body weight (g) (n=5 each)	Mean daily consumption of treated bait (g/100g bwt)	Total consumption of treated bait (g/100g bwt)	Total cellulose consumed in 8 days (g/100g bwt)
No-choice	25	118.0	9.12[a]	72.92[a]	18.23[a]
Bi-choice	25	117.8	5.04[b]	40.30[b]	10.08[b]
No-choice	50	110.2	9.43[a]	75.46[a]	37.73[a]
Bi-choice	50	112.0	4.08[b]	32.62[b]	16.31[b]

Values with different superscripts (a-b) in a column differ significantly at $P<0.05$, No mortality was achieved in any treatment

responsive throughout the baiting process. No fur loss or signs of inactivity were observed in our study. In contrast, Issa et al., (2021) reported significant adverse effects, including fur loss, weight loss, sunken eyes, immobility, and insensitivity in rats treated with agricultural waste containing cellulose as the active ingredient.

CONCLUSIONS

The laboratory and field experiments, which examined the rodenticidal potential of cement and cellulose baits over 4-8 days, unequivocally revealed *no* toxic effects. This strongly suggests that cement and cellulose are not viable alternatives to chemical rodenticides. Extending the exposure period further is unlikely to yield positive results and would only increase labour and costs, making it an impractical solution. Therefore, further research must be conducted to identify truly effective and environmentally friendly alternatives for rodent pest management.

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