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Microencapsulated citronella oil: A novel antifeedant and repellent for managing house rats (*Rattus rattus*)

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This study presents an innovative, eco-friendly approach to rodent deterrence through sodium alginate-based microencapsulation of citronella oil, designed to enhance its stability, longevity, and efficacy against house rats (*Rattus rattus* Linnaeus). Microcapsules containing 3%, 4%, and 5% oil were incorporated into bait at 5%, 10%, and 20% concentrations and assessed for antifeedant and repellent activity under controlled laboratory and simulated storage conditions. The 5% oil microcapsules, delivered at 20% bait concentration, demonstrated the highest and most sustained antifeedant response, achieving 90.62% deterrence maintained across all 7 days. Repellency consistently ranged from 77.05% to 92.23%, with the 5% formulation outperforming the others throughout the exposure period. Maze assays confirmed a strong behavioural avoidance, as rats markedly reduced their presence in treated zones. Under simulated storage conditions, jute bags containing wheat grains and sprinkled with 5% oil microcapsules showed significant reductions in grain loss, spillage, and bag damage for up to 10 days. Effects peaked on day 2 and remained functionally effective thereafter. This work highlights microencapsulated citronella oil as a promising, sustainable, and non-toxic alternative to chemical rodenticides, offering an innovative strategy for protecting stored commodities and mitigating rodent-related losses.

Keywords: Behavioural avoidance, Eco-friendly rodent management, Essential oil formulation, Plant-derived bioactive compounds, Sustained release technology

Table 1S — Antifeedant effect of baits containing microcapsules loaded with 3% citronella oil on *Rattus rattus*(n = 6 each)

Days of treatment	5% in bait		Antifeedant index (%)	10% in bait		Antifeedant index (%)	20% in bait		Antifeedant index (%)
	Mean daily bait consumption (g/100g bwt)			Mean daily bait consumption (g/100g bwt)			Mean daily bait consumption (g/100g bwt)		
	Treated side	Untreated side		Treated side	Untreated side		Treated side	Untreated side	
1	1.64±0.27 ^{abc}	9.52±0.75*	69.64±5.51 ^{abc}	1.22±0.25 ^{bc}	10.32±0.40*	79.13±3.71 ^{ab}	0.68±0.26 ^b	10.76±0.79*	86.97±5.28 ^a
2	0.47±0.11 ^d	9.16±0.81*	89.59±2.46 ^a	0.48±0.11 ^d	9.89±0.43*	90.49±2.19 ^a	0.61±0.19 ^b	9.54±0.57*	88.67±3.19 ^a
3	0.85±0.21 ^{cd}	8.08±0.73*	81.53±4.61 ^{ab}	0.68±0.21 ^{cd}	8.76±0.43*	85.88±4.60 ^a	0.65±0.22 ^b	9.52±0.63*	87.49±3.76 ^a
4	1.28±0.14 ^{bcd}	6.77±0.59*	67.06±5.10 ^{abc}	0.46±0.10 ^d	8.56±0.29*	89.60±2.36 ^a	0.54±0.08 ^b	8.54±0.76*	88.05±1.62 ^a
5	1.54±0.28 ^{abc}	5.40±0.84*	50.84±12.88 ^{bcd}	1.37±0.10 ^b	7.13±0.33*	67.77±2.04 ^{bc}	0.72±0.20 ^b	7.84±0.69*	82.33±5.23 ^{ab}
6	2.22±0.18 ^{ab}	3.22±0.61	31.29±6.56 ^d	1.48±0.13 ^b	5.96±0.55*	58.92±5.07 ^c	1.32±0.20 ^{ab}	6.79±0.55*	67.45±4.53 ^b
7	2.30±0.37 ^a	1.14±0.32	41.80±14.48 ^{cd}	2.14±0.23 ^a	4.12±0.46*	31.36±6.49 ^d	1.62±0.19 ^a	4.92±0.43*	50.18±4.82 ^c
Average	1.47±0.27	6.19±1.28*	61.68±8.66	1.12±0.25	7.82±0.91*	71.88±8.72	0.88±0.17	8.27±0.80*	78.73±5.98

Values are Mean±SE, Mean values with * indicate significant difference in consumption between treated and untreated baits at $P \leq 0.05$, Mean values with different superscripts (a-d) indicate a significant difference among days at $P \leq 0.05$