Drug release kinetics study

The *in-vitro* drug release study for encapsulated Biopolymer beads (CNN, CLN, EGN Beads) under stable Ph 7 and ionic strength. For the analysis, 1g of beads is dispersed in 1X PBS buffer (100ml) each time, and the taken volume is replaced with fresh medium. Drug release data was collected at different intervals of time (0,1,2,4,6,8,12,24,36.48,60,72,84,96,108,120 hrs) and examined under UV-Vis spectrophotometer. Based on the absorbance value, maximum drug release values were calculated.

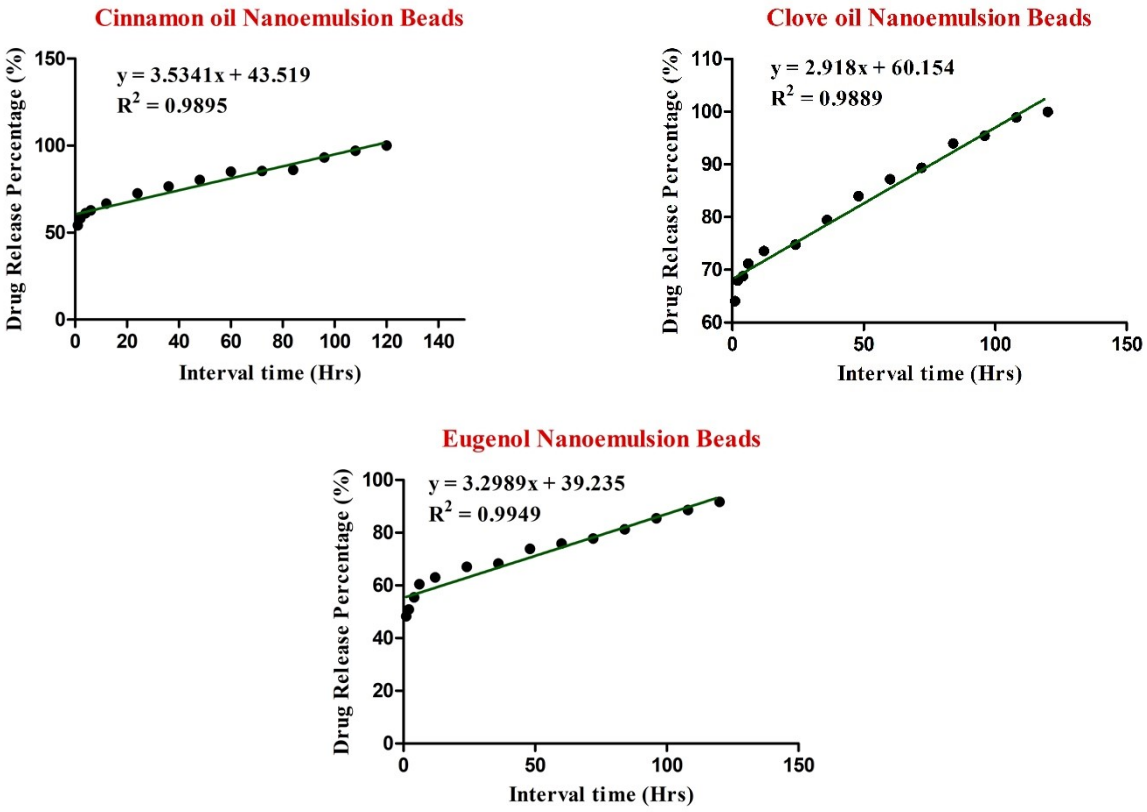


Fig. S1: Release kinetics of the nanoemulsion beads over a period of 150 hrs.

The cumulative drug release (CDR) that is the amount of nanoemulsion released during a period of 150 hrs is calculated based on the following formula

$$\text{CDR \%} = \frac{\textit{Absorbance value at time } (t)}{\textit{Total amount of drug encapsulated with delivery system}} \times 100$$

Dose dependent curve

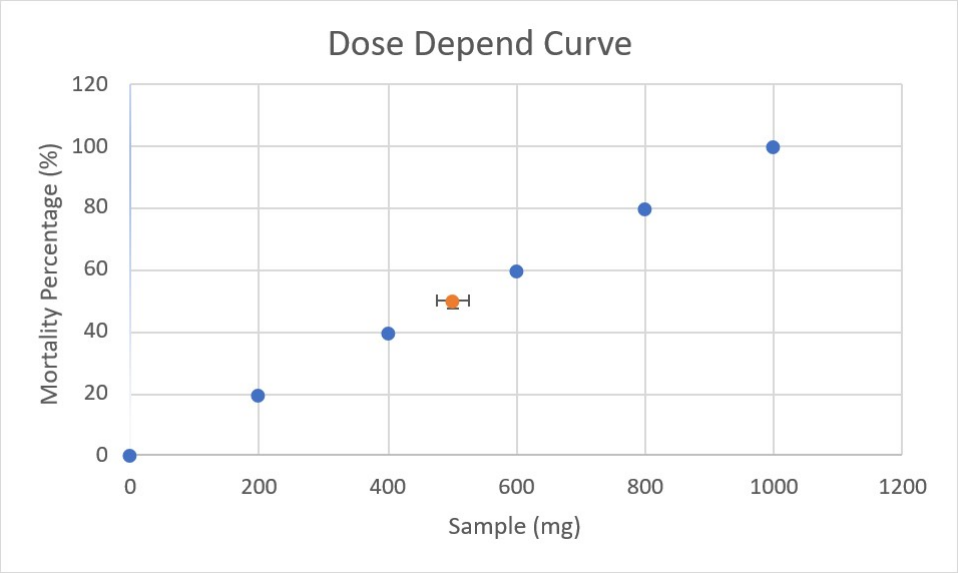


Fig. S2: Dose dependent curve

In-vitro statistical assessment analysis

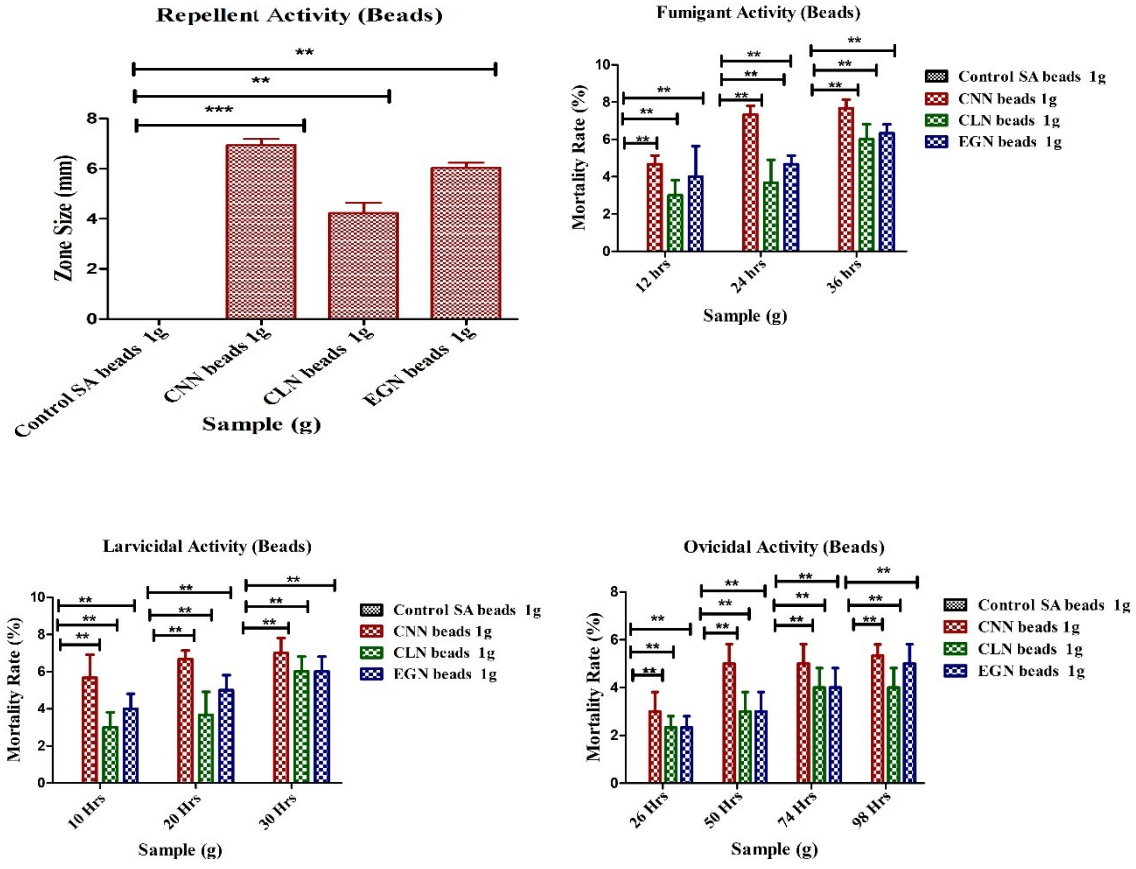


Fig. S3: Statistical analysis of invitro assessment of NEs beads against *T. castaneum*

Table S1: Cinnamon nanoemulsion beads release kinetics

S.NO	Interval time (Hrs)	Drug Released Percentage (%)	Drug Remaining Percentage (%)
1	1	54.15	45.85
2	2	58.17	41.82
3	4	61.18	38.86
4	6	62.74	37.16
5	12	66.74	33.25
6	24	72.56	27.43
7	36	76.56	23.43
8	48	80.32	19.60
9	60	85.10	14.89
10	72	85.46	14.54
11	84	86.02	13.97
12	96	93.14	6.85
13	108	97.00	2.99
14	120	100	0

Table S2: Clove oil nanoemulsion beads

S.NO	Interval time (Hrs)	Drug Released Percentage (%)	Drug Remaining Percentage (%)
1	1	64.06	35.97

2	2	67.93	32.09
3	4	68.75	31.24
4	6	71.20	28.79
5	12	73.56	26.73
6	24	74.78	25.21
7	36	79.44	20.55
8	48	83.97	16.02
9	60	87.19	12.80
10	72	89.33	10.66
11	84	93.98	6.01
12	96	95.43	4.56
13	108	98.87	1.12
14	120	99.98	0.02

Table S3: Eugenol nanoemulsion beads

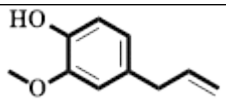
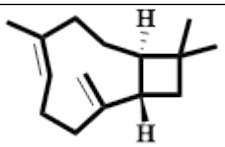
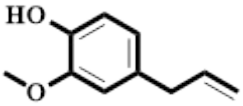
S.NO	**Interval time (Hrs)**	**Drug Released Percentage (%)**	**Drug Remaining Percentage (%)**
1	1	48.29	51.70
2	2	50.90	49.09
3	4	55.45	44.54
4	6	60.44	38.55
5	12	63.01	36.98

6	24	67.07	32.99
7	36	68.28	31.71
8	48	73.88	26.11
9	60	75.91	24.08
10	72	77.77	22.22
11	84	81.32	18.67
12	96	85.49	14.50
13	108	88.58	11.41
14	120	91.66	8.33

Table S4: The optimization of the essential oil concentration

Final Volume	**Essential Oil (µL)**	**Surfactant (µL)**	**Water (µL)**
1 mL	40	100	880
2 mL	80	200	1760
3 mL	120	300	2640
4 mL	160	400	3520
5 mL	200	500	4400
6 mL	240	600	5280
7 mL	280	700	6160
8 mL	320	800	7040
9 mL	360	900	7920
10 mL	400	1000	8800

Table S5: GC-MS chromatogram of CNN, CLN and EGN with retention time

Essential Oil Beads	Retention time	Compounds	Mass	Structure
Cinnamon nanoemulsion	9.29, 10.10	Eugenol	164	
Clove nanoemulsion	10.11, 11.38	Beta-Caryophyllene	204	
	9.11,9.29,10.57	Eugenol	164	
Eugenol nanoemulsion	9.02, 9.15, 9.30, 11.48	Eugenol	164