

Article

Essential oil-based nano-biopesticides: formulation and bioactivity against *Tribolium confusum*

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Supplementary Table S1. GC-MS analysis of the selected EOs.

^a Calculated Linear Retention Index

Component	LRI ^a	<i>Pimpinella anisum</i> (%)	<i>Artemisia vulgaris</i> (%)	<i>Foeniculum vulgare</i> (%)	<i>Allium sativum</i> (%)	<i>Lavandula angustifolia</i> (%)	<i>Mentha piperita</i> (%)	<i>Rosmarinus officinalis</i> (%)	<i>Salvia officinalis</i> (%)
allyl methyl sulfide	699				0.57				
dimethyl disulfide	739				0.04				
hexan-2-one	797				0.03				
4-Methylthiazole	822				0.01				
allyl isopropyl sulfide	826				0.01				
furfural	832				0.01				
1,2-dithiolane	842				0.04				
unknown 1	851		0.23						
diallyl sulfide	857				11.09				
allyl propyl sulfide	872				0.04				
allyl methyl disulfide	914				2.3				
tricyclene	924		0.86						
α -thujene	928					0.05			0.21
methyl propyl disulfide	930				0.01				
α -pinene	934	0.51	0.61	2.63		0.91	1.98	11.28	21.2
2-ethoxythiazole	944				0.01				
methyl (E)-1-propenyl disulfide	947				0.13				
camphene	947		3.97	0.31		0.13		3.01	4.67
(E)-2-hexenal	952				0.03				
verbenene	953		0.18						
3H-1,2-dithiolene	957				0.13				
dimethyl trisulfide	967				0.02				
benzaldehyde	969				0.02				
sabinene	971	0.03	0.62	0.09		0.11	0.34	0.19	
β -pinene	974	0.16	0.4	0.98		0.23	0.99	4.01	0.23
3-(methylthio)-1-propanol	979				0.01				
1,2,4-trimethylbenzene	986		0.2						
β -myrcene	989	0.1	1.75	1.1		0.37	0.12	1.7	1.2

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α -phellandrene	1002	0.31	0.04	2.52				0.42	0.1
δ -3-carene	1010	0.12		0.31				0.3	0.04
1,2,3-trimethylbenzene	1014		0.25						
α -terpinene	1014			0.41				2.01	0.81
p-cymene	1014	0.02	1.52	2.1		0.31			2.14
m-cymene	1018	0.12							
o-cymene	1019							4.01	
β -phellandrene	1025	0.19	0.93						
limonene	1026	1.14		32.96			7.73		
eucalyptol	1026		4.21			5.01		52.72	20.7
(Z)- β -ocimene	1024			0.5		0.58		0.05	
(E)- β -ocimene	1044					0.27			
allyl isopropyl disulfide	1050				0.14				
γ -terpinene	1054	0.21	0.33	0.17		0.09		0.99	1.54
trans-Sabinene hydrate	1063					0.13			
1-(Methylthio)-3-pentanone	1067				0.01				
linalool oxyde	1069					0.06			
fenchone	1075			7.67					
diallyl disulfide	1080				30.09				
terpinolene	1085	0.05	0.12	0.2		0.06		0.5	0.52
unknown 2	1089		1.16						
allyl (Z)-1-propenyl disulfide	1093				0.19				
α -thujone	1093		28.42						16.23
linalool	1094	1.94		0.73		38.12		0.67	
allyl (E)-1-propenyl disulfide	1099				0				
β -thujone	1103		13.35						4.42
chrysanthenone	1109		5.97						
(Z)- β -terpineol	1118		0.84						
camphor	1129	0.04	22.21	0.1		7.01		12.04	12.85
trans-pinocarveol	1135		1.01						
unknown 3	1135							0.04	

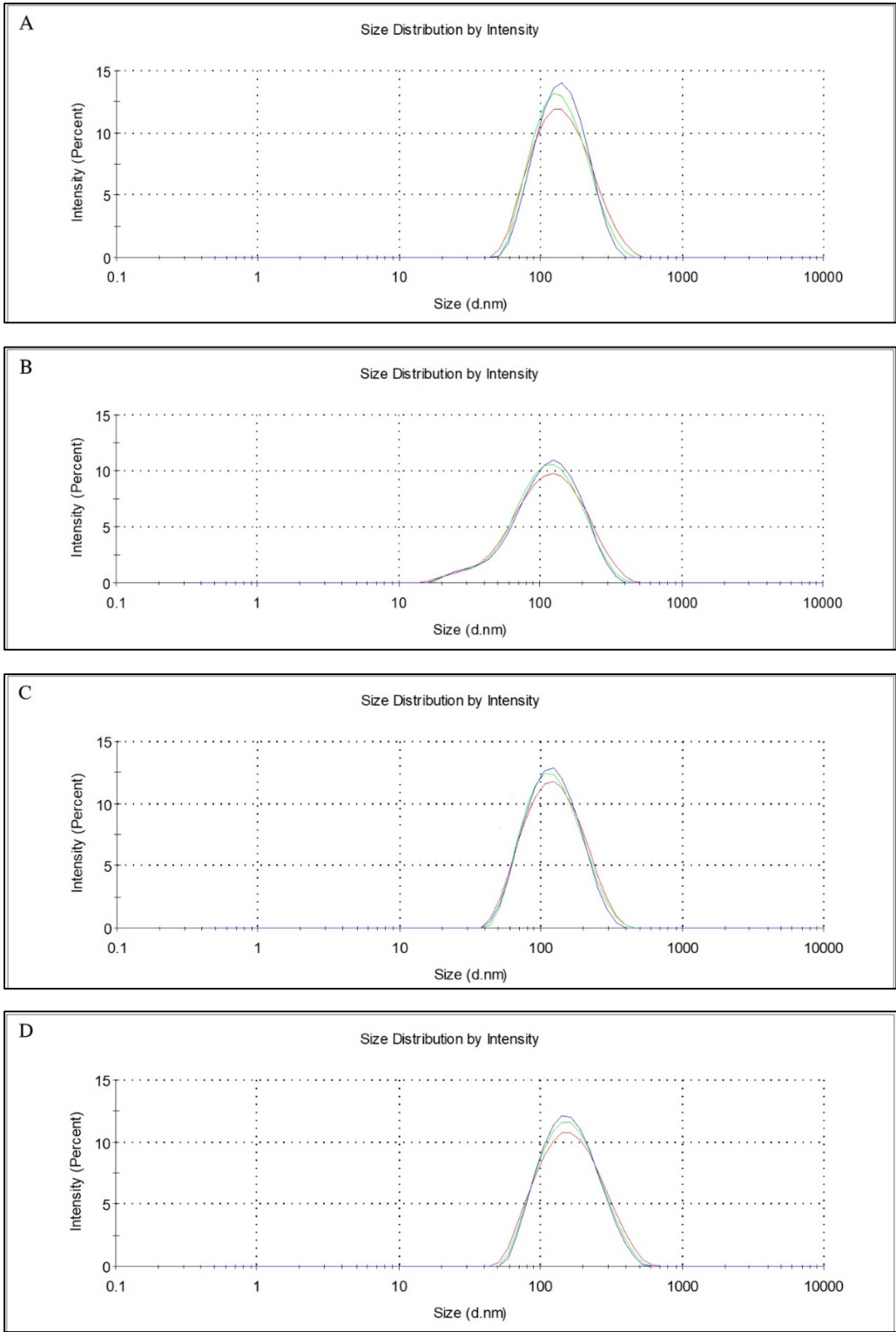
Component	LRI ^a	<i>Pimpinella anisum</i> (%)	<i>Artemisia vulgaris</i> (%)	<i>Foeniculum vulgare</i> (%)	<i>Allium sativum</i> (%)	<i>Lavandula angustifolia</i> (%)	<i>Mentha piperita</i> (%)	<i>Rosmarinus officinalis</i> (%)	<i>Salvia officinalis</i> (%)
allyl methyl trisulfide	1138				3.31				
menthone	1140						22.1		
pinocarvone	1149		0.19						
isomenthone	1149						8.75		
isoborneol	1153					0.41			
4-methyl-1,2,3-trithiolane	1156				0.99				
menthofurane	1156						1.1		
unknown 4	1158							0.22	
(-) neomenthol	1159						6.32		
borneol	1161		0.96			2.67		1.05	3.1
methyl (E)-1-propenyl trisulfide	1166				0.01				
(-) menthol	1170						37.67		
terpinene-4-ol	1171	0.18	0.69	0.17		1.74		0.42	
4,5-dimethyl-2-propylthiazole	1174				0.01				
hexyl butyrate	1181					0.19			
α -terpineol	1184	0.15				0.26	0.91	1.1	
estragol	1187	3.98		2.1					
3-vinyl-4H-1,2-dithiine	1189				0.03				
α -phellandrene epoxide	1195			0.21					
4H-1,2,3-trithiine	1200				0.02				
allicin (diallyl thiosulfinate)	1208				0.02				
2 vinyl-4H-1,3-dithiine	1215				0.03				
pulegone	1224						0.95		
4,5-dimethyl-2-butylthiazole	1226				0.08				
s-(+)carvone	1226						1.66		
p-anisaldehyde	1235	0.41		0.72					
piperitone	1237						0.98		
(Z)-anethole	1243	0.21		0.3					
linalyl acetate	1252					36.31			

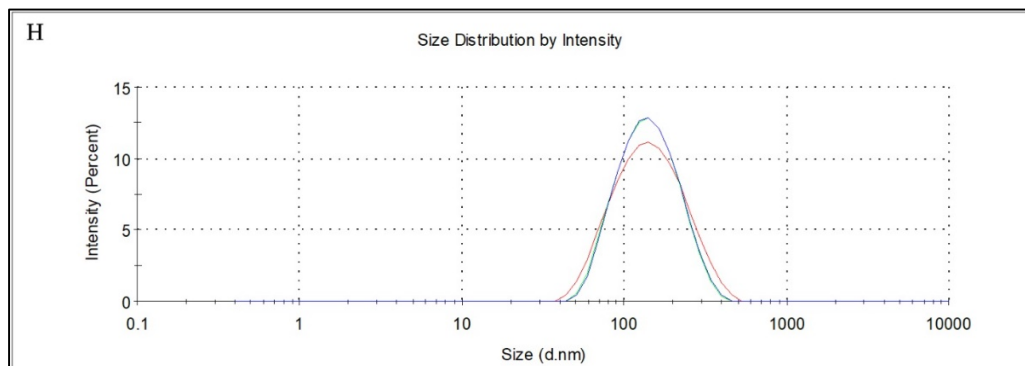
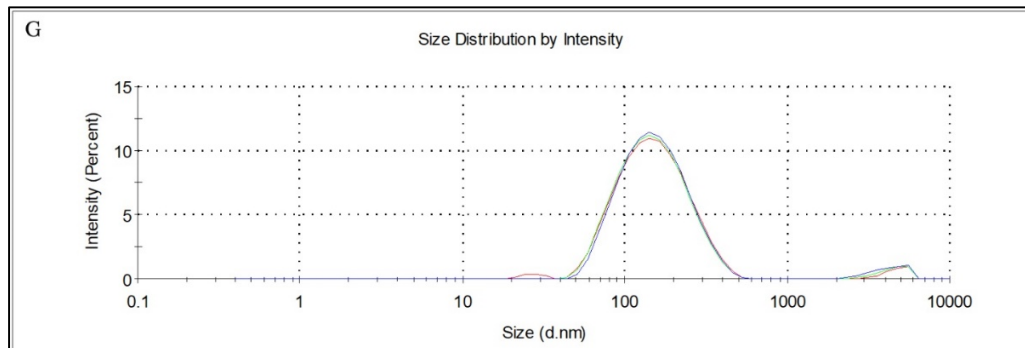
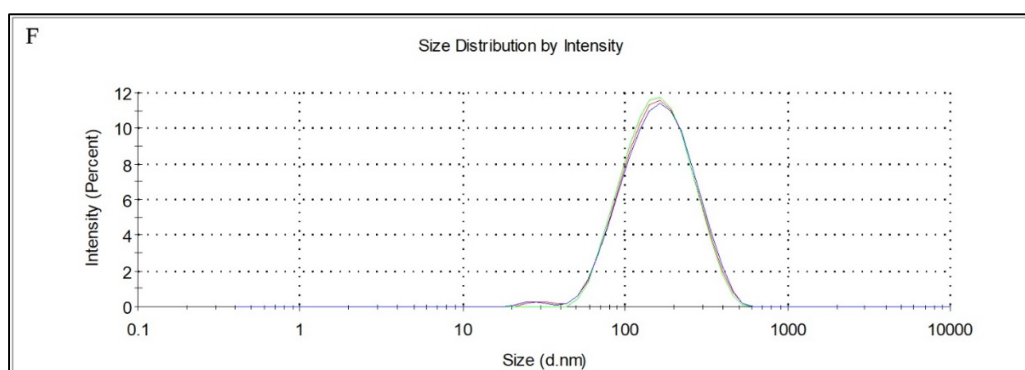
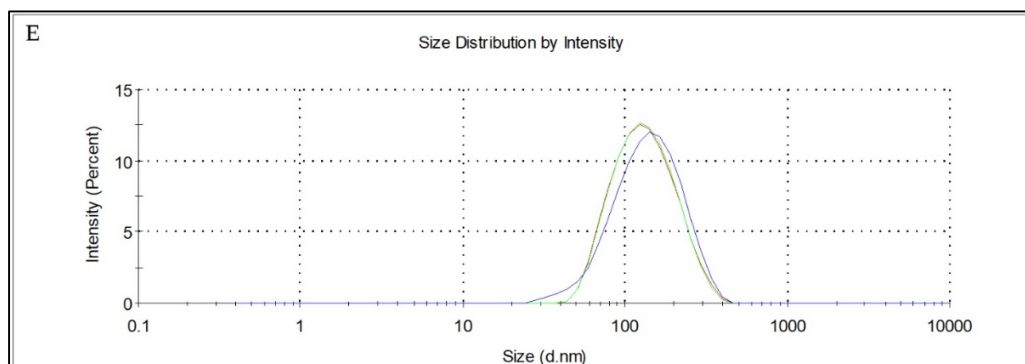
Component	LRI ^a	<i>Pimpinella anisum</i> (%)	<i>Artemisia vulgaris</i> (%)	<i>Foeniculum vulgare</i> (%)	<i>Allium sativum</i> (%)	<i>Lavandula angustifolia</i> (%)	<i>Mentha piperita</i> (%)	<i>Rosmarinus officinalis</i> (%)	<i>Salvia officinalis</i> (%)
α -cedrene	1418					0.02			
unknown 6	1419	0.04			0.2				
β -caryophyllene	1425	0.21	0.7			2.21	1.74	2.1	3.9
3,6-dimethyl-1,2,5-trithiepane	1428				0.01				
β -cubebene	1433						0.5		
unknown 7	1439					0.3			
α -bergamotene	1439	0.25	0.19						
4-ethyl-2,3,5-trithia-6-octene	1444				0.36				
β -farnesene	1454	0.01				0.61			
α -humulene	1459					0.32	0.12		3.99
4,6-dimethyl-1,2,5-trithiepane	1460				0.06				
α -elemene	1474					0.05			
γ -muurolene	1479					0.06	0.03		
germacrene D	1484		0.8			0.32	0.39		
δ -guaiene	1485								0.04
germacrene B	1501		0.04				0.13		
α -farnesene	1503	0.02							
α -bisabolene	1508	0.07				0.13			
β -cadinene	1511							0.01	
γ -muurolene	1515	0.01							
γ -cadinene	1515					0.14	0.06		
β -sesquiphellandrene	1521					0.13			
δ -cadinene	1524	0.05					0.17	0.19	
diallyl tetrasulfide	1544				13.17				
(E)-nerolidol	1558	0.06							
allyl methyl pentasulfide	1573				0.01				
(+) spathulenol	1579						0.03		
caryophyllene oxyde	1582					0.1	0.18	0.16	0.1
7-methyl-4,5,8-trithia-1,10-undecadiene	1583				0.34				

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4-ethyl-6-methyl-1,2,3,5-tetrathiolane	1588				0.05				
6-methyl-4,5,8-trithia-1,10-undecadiene	1592				1.19				
2-thiopheneacetamide, N-propyl-	1622				0.05				
4-methyl-1,2,3,5,6-pentathiepane	1649				0.22				
t-muurolol	1654	0.06							
6-ethyl-4,5,7,8-tetrathianonane	1658				0.15				
2-thiopheneacetamide, N-isobutyl-	1663				0.21				
foeniculin	1666	2.01		0.51					
α -bisabolol	1678					0.1			
hexathiepane	1680				0.24				
diallyl pentasulfide	1755				0.5				
allyl methyl hexasulfide	1781				0.51				
8-methyl-4,5,6,9-tetrathia-1,11-dodecadiene	1815				5.89				
diallyl hexasulfide	1897				0.26				
allyl methyl heptasulfide	1922				0.16				
2-methyl-1,3-benzothiazole	1957				0.36				
5-ethyl-7-pentyl-1,2,3,4,6-pentathiepane	2005				0.32				
cyclooctasulfur	2044				0.08				
9-methyl-4,5,6,7,10-pentathia-1,12-tridecadiene	2051				0.9				

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8-methyl-4,5,6,7,10-pentathia-1,12-tridecadiene	2056				0.68				
Monoterpene		2.96	11.33	44.28		3.11	11.16	28.47	32.66
Oxygenated monoterpene		2.31	84.52	8.88		87.88	80.65	68.52	58.64
Sesquiterpene		0.69	2.31			4.43	4.05	2.59	8.6
Oxygenated sesquiterpene		0.12				0.2	0.21	0.16	0.1
Phenylpropene		93.72		46.84			3.93		
Ester						0.19			
Sulphur compounds					99.8				
Aromatic hydrocarbon			0.45						
Total identified		99.80	98.61	100.00	99.80	95.81	100.00	99.74	100.00

Supplementary Figure S1. Dimensional values of nanoemulsions containing anise(A), artemisia(B), fennel(C), garlic(D), lavender(E), mint(F), rosemary(G) or sage(H) EO.





Supplementary Figure S2. ζ potential values of nanoemulsions containing anise(A), artemisia(B), fennel(C), garlic(D), lavender(E), mint(F), rosemary(G) or sage(H) EO.

