FJARD VOL. 38, NO. 4. PP. 524–534(2024)

Fayoum Journal of Agricultural Research and Development
ISSN:1110-7790
ONLINE ISSN:2805-2528

Molluscicidal and antifeedant effects of some botanical oils against the land snail *Monacha obstructa* snail (Gastrda: Hygrmiidae)

Ibrahim H. Hussein[1], Salwa M. Abd El Halim[1], Marguerite A. Rizk[2], Amal A. Fkreen[1,*]

[1]Department of Plant Protection, Faculty of Agriculture, Fayoum University, Fayoum 63514, Egypt
[2]Plant Protection Research Institute, Agricultural Research Center (ARC), Giza, Egypt

التأثيرات الإبادية والمضادة للتغذية لبعض الزيوت النباتية على قوقع البرسيم الزجاجي

ABSTRACT

The molluscicidal and antifeedant activities of six botanical oils namely sweet basil (*Ocimum basilicum*), clove (*Eugenia aromaticum*), peppermint *Mentha piperita*, garlic (*Allium sativum*), chamomile (*Artemisia herba*-alba) and geranium (*Pelargonium graveolens*) were tested against the adult stage of *Monacha obstructa* (Gastropoda: Hygromiidae) under laboratory conditions. The results indicated that using contact and spraying methods, sweet basil oil was the most toxic based on IC50 values. Chamomile and clove oils were the least efficient using the same methods. Also, sweet basil oil caused 82.4% inhibition in feeding activity to the land snail *M. obstructa* at 4 mg/ml. This inhibition was 74.3% by garlic oil and 57.1 % by chamomile oil at the same concentration. Therefore, garlic oil at the IC_{50} level and sweet basil at the IC_{90} level appeared the more potent as feeding deterrents while chamomile oil was the lower effective of both levels. Conversely, botanical oils of clove, geranium and peppermint exerted negative antifeeding effects. Moreover, twenty essential oils were identified by GC/MS analysis in sweet basil. These oils were divided into twelve monoterpene hydrocarbons (70.83%) and eight sesquiterpene hydrocarbons (19.17%). It is evident that linalool (35.90%) was the most abundant compound followed by eucalyptol (12.73%) and α-farnesene (8.68%). While, among the identified compounds were eugenol (7.64%), γ-muurolene (5.42%), α-humulene (2.39%) and *β*-pinene (1.03%). It is worth noting that sweet basil exhibited strong molluscicidal and antifeedant activities against the adults of *M. obstructa* and may be that the detected oils are responsible for causing this activity. The current study showed safe alternatives from plant origin such as sweet basil oil which may be used as a botanical molluscicide to control land snails or as antifeedant to protect the crops from them.

Keywords: Botanical oils, Antifeeding effect, *Monacha obstructa*, Chemical constituent, GC/MS analysis

*Correspoinding author E-mail: amlfkryn@gmail.com
Submit date: 08-05-2024
Revise date: 15-07-2024
Accept date: 23-10-2024

1. INTRODUCTION

Terrestrial snails are considered very serious pests resulting in significant loss of several agricultural crops causing a severe. damage to fruit trees as well as field crops, vegetables and ornamental plants in many countries **(Nakhla *et al*., 2002; Abdel-Rahman, 2017; Idris *et al*., 2020).** The harmful land snail *Monacha obstructa*, (Gastropoda: Hygromiidae) is one of the most prevalent snails in Egypt **(Ali *et al*., 2020; Mesbah *et al*., 2022)**. Botanical oils can be successfully used in controlling land snails. Dill and fennel oils exhibited strong molluscicidal and antifeedant activities against *Theba pisana* land snails **(El-Zemity and Radwan, 2001)**. Also, the essential oils of *Origanum vulgare* and *Artmisia judaica* appeared fumigant toxicity on *T. pisana* **(Saad and Abou-Taleb, 2015)**. Therefore, the essential oils extracted from plants act as safe alternatives replace synthetic pesticides in pest control regardless of whether they are toxic or repellent. It is known that synthetic pesticides lead to environmental pollution and pest resistance with their effects on beneficial living organisms and phytotoxicity. So the search was for new, influential and natural materials represented in the plant kingdom which is a rich source for finding this and among them was botanical oils. The toxic impact of botanical oils against the land snail *Monacha obstructa* was reported by other researchers **(Shoaib *et al*., 2010; Mourad, 2014; Farag and Sabry, 2017; Abdel-Rahman, 2020; Abobakr *et al*., 2022)**. The objective of the present investigation is to study the molluscicidal and antifeedant effects of six botanical oils namely: sweet basil, clove, peppermint, geranium, garlic and chamomile against the adult stage of land snail *M. obstructa* beside identification of chemical components of the more active oil using GC/MS analysis.

2. MATERIALS AND METHODS

2.1. Tested land snails

Adults of land snail *Monacha obstructa* were collected from infested alfalfa (*Medicago sativa* L.) field at Khaldia village, Abshwai district, Fayoum governorate. The obtained snails transferred to the laboratory in polyethylene bags. Healthy individuals and approximately the same shells diameter about (11-13 mm) for all experiments were selected and caged in plastic boxes (15 × 12 × 4 cm) and supplied with fresh leaves of lettuce. The snails were acclimatized for two weeks before bioassay and starvation for 24 h. Dead snails were removed immediately and discarded **(Eshra, 2014)**.

2.2. Tested botanical oils

Six botanical oils were selected for this study namely: sweet basil (*Ocimum basillicum* L.), geranium (*Pelargonium graveolens* L.), clove (*Eugenia aromaticum* L.), garlic (*Allium sativum* L.), peppermint (*Mentha piperita* L.) and chamomile (*Artemisia herba-alba* L.) extract steam distillation method **(Gunther, 1948)**. Commercial plant essential oils were obtained from The National Research Center. These botanical oils were kept in a refrigerator until used. A series of aqueous concentrations of each essential oil was prepared with 0.5 ml tween 80 as an emulsifier.

2.3. Laboratory tests

Three different tests were carried out in the laboratory using six botanical oils assayed on the land snail *M. obstructa* adult.

2.3.1. Spraying test

The tested essential oils were applied as spray solution by atomizer on the adults of *M. obstructa* (3 ml/10 snails) in plastic boxes with green lettuce. Ten adults were placed in

each box and four replicates were used after that treated by being sprayed with different concentrations (40, 20, 10, 5 and 2.5 mg/ml) of essential oil prepared with 0.5 ml tween 80 as a surfactant. Untreated control was sprayed only with distilled water with tween 80. Mortality was estimated for snails after 24 hours of spraying and corrected by using **Abbott (1925)** formula as follows:

$$\text{Corrected mortality (\%)} = \frac{\text{Observed mortality} - \text{Control mortality}}{100 - \text{Control mortality}} \times 100$$

2.3.2. Residual film (contact) test

Residual film technique was used according to **Ascher and Marian (1981)**. The test involves five concentrations of the treated plant essential oils being applied using 1ml of each concentration deposited on the surface of petri dish 9 cm dia., by moving the box gently in circles and the solution is allowed for uniform spreading and then leaving it to dry up at room temperature. Each concentration was replicated four times and each replicate contained ten adult snails per dish which were exposed to the concentrations as a thin film. Mortality percentages were calculated after 24 h of treatment and the obtained results were corrected for the natural mortality using **Abbott' (1925)** formula as mentioned before. The untreated check was done by adding 40 adult snails to the empty dish

2.3.3. Antifeedant test

Homogenous discs (5 g) of fresh lettuce leaves were treated with the tested concentrations (4, 2, 1, 0.5 and 0.25 mg/ml) of each plant oil using 1 ml pipette. Plant discs were placed in a plastic box in three replications for every concentration. Ten adults were introduced into each box, 12cm dia. Control discs were treated with distilled water and 0.5 ml tween 80 alone. The consumption of leaf material was recorded by reweighed after 24 hours of feeding. The antifeeding effect was measured as an inhibition percentage in feeding activity and was corrected according to the following formula **(Barratt *et al.*, 1993)**

Inhibition (%) = (C-T)/C × 100, where: C = mean weight gain of control discs within 24 h and T= mean weight gain of treated discs within 24 h.

2.4. Identification by gas chromatography-mass spectrometry (GC/MS) analysis

The GC column was 30 m (025 mm i.d., film thickness 0.25 Mm) HP-SMS (5% diphenyl) dimethylopolysiloxane capillary column. The GC conditions were as follows; injector temperature, 240 °C; column temperature, isothermal at 50 °C for 2 min, then at this temperature for programmed to 280" C at 6 °C/min and held at this temperature for 2min; ion source temperature, 200° C; detector temperature, 300C. Helium was used as the carrier gas at the rate of 1 ml/min. The effluent of the GC column was introduced directly into the ion source of the MS. Spectra were obtained in the EI mode with 70 eV ionization energy. The sector mass analyzer was set to scan from 40 to 400 amu for 5 s Gas chromatography–mass spectrometry analysis (GC-MS) was carried out using agilent auto system 7890B GC-MS equipped with HB-5MS capillary column (5% phenyl–95% dimethyl polysiloxane, 30 m × 0.25 mm × 0.25 μm). These data were obtained from environmental and food pollutants laboratory at Faculty of Agriculture, Fayoum University.

2.5. Statistical analysis

Toxicological data obtained were subject to statistical analysis to evaluate the relative efficiency of the tested plant oils. Mortality percentages were adopted using probit analysis program according to the

method developed by **Finney (1971)** to estimate the concentration required to kill 50 and 90% (LC_{50} and LC_{90}) as well as the concentrations which caused 50 and 90% inhibition (IC_{50} and IC_{90}). The values of slope ± SE and chi-square (χ^2) were also determined. Withal, the data were statistically analyzed according to **Snedecor and Cochran (1980)**. Means were compared using the least significant difference (LSD) test at 0.05 level of probability.

3. RESULTS AND DISCUSSION

3.1. Toxicity of some botanical oils against the adult stage of *M. obstructa*

The effect of six botanical oils namely: clove, garlic, peppermint, sweet basil, chamomile and geranium as spraying and contact were tested

3.2. Botanical oils as spray solutions

Data in Table 1 indicate that sweet basil oil was the most effective with LC_{50} of 5.23 mg/ml followed by peppermint and garlic oils with LC_{50} values of 19.7 and 22.2 mg/ml respectively. Clove oil was the least toxic with LC_{50} of 51.4 mg/ml, the LC_{90} values followed the same order as that of LC_{50}. Therefore, sweet basil was the most toxic with LC_{90} of 24.3 mg/ml while clove was the least toxic with LC_{90} value of 465 mg/ml. The relative potency at the LC_{50} and LC_{90}values elucidated that sweet basil oil had 9.83 and 19.1 folds as effective as clove oil. Likewise, garlic oil at the same values were 2.31 and 5.67 folds more toxic than clove oil. Thus, toxicity index illustrated that clove at the values of LC_{50} and LC_{90} were 10.2 and 5.22% as toxic as sweet basil. Withal, garlic oil at the same values were 23.6 and 29.6% lower potent than sweet basil.

Table 1. LC_{50}, LC_{90}, slope, toxicity index and relative potency values of some botanical oils of *M. obstructa* adults using spraying technique

Oil	LC_{50} (mg/ml)	95% confidence limits		LC_{90} (mg/ml)	95% confidence limits		Slope±SE	Toxicity index (%) at		Relative potency (fold) at	
		Lower	upper		Lower	upper		LC_{50}	LC_{90}	LC_{50}	LC_{90}
Sweet basil	5.23	3.849	6.678	24.3	17.42	41.16	1.92± 0.27	100	100	9.83	19.1
Peppermint	19.7	44.35	131.6	89.2	56.09	194.7	1.95±0.28	26.5	27.2	2.60	5.21
Garlic	22.2	17.79	29.47	82.0	54.46	161.7	2.25± 0.31	23.6	29.6	2.31	5.67
Chamomile	39.3	27.67	71.52	219	106.1	930.9	1.72± 0.30	13.3	11.1	1.30	2.12
Geranium	48.4	35.34	88.21	170	92.09	661.8	2.35±0.46	10.8	14.3	1.06	2.74
Clove	51.4	31.74	138.2	465	162.9	5239	1.34± 0.27	10.2	5.22	1.0	1.00

LC_{50}: Concentration which is lethal to 50% of a population of test animals. LC_{90}: Concentration which is lethal to 90% of a population of test animals.

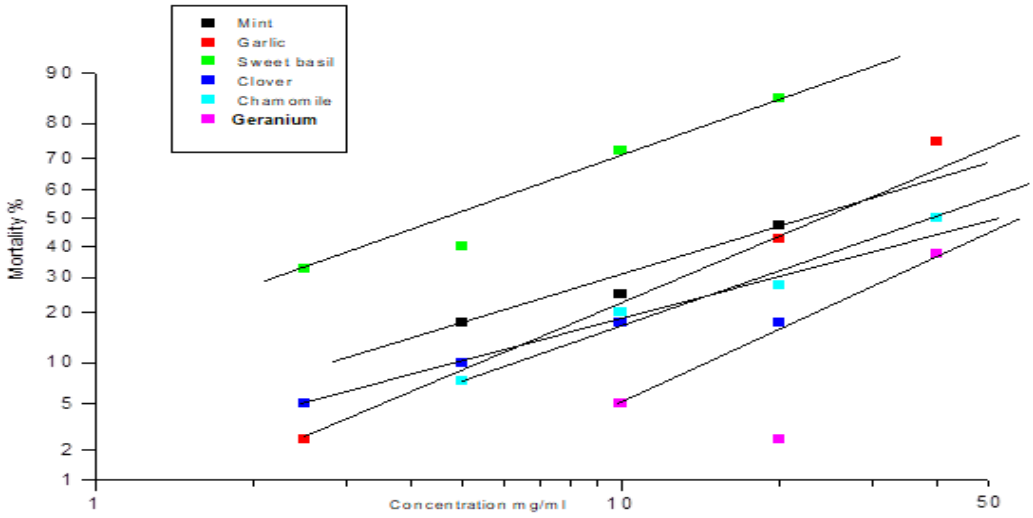

Fig. 1. Toxicity lines of essential oils by spraying technique.

3.3. Botanical oils as contact poisons

Data presented in Table 2 revealed that sweet basil oil as a residual film proved to be the highly toxic with LC_{50} values of 7.70 mg/ml followed by clove and peppermint oils with LC_{50} of 8.18 and 8.39 mg/ml respectively. Based on LC_{90} level, only peppermint and clove oils were more toxic than sweet basil, this level for peppermint and clove oils were 34.9 and 36.0 mg/ml while, sweet basil was 54.2 mg/ml. Chamomile oil was the lower efficient with LC_{50} and LC_{90} were 26.9 and 240 mg/ml respectively. The relative potencies, at the LC_{50} and LC_{90} values exhibited that sweet basil oil had 3.49 and 4.42 times more potent than chamomile oil. Therefore, the toxicity index showed that chamomile had 28.6 and 14.5% as effective as sweet basil at LC_{50} and peppermint at LC_{90} respectively. Toxic action of botanical oils as molluscicides was also reported by **El-zemity and Radwan (2001)** using garlic, geranium, and peppermint oils on *Theba pisana*, **Ismail *et al.* (2011)** using clove oil on *Monacha cartusiana*, **Farag and Sabry (2017)** using sunflower and soybean oils on *M. cartusiana*, **Idris *et al.* (2020)** using citronella and clove oils on *Pomaceoa canaliculate*, **Mesbah *et al.* (2022)** using neem and peppermint oils on *T. pisana*, and *Eobania vermiculata* and **Abobakr *et al.* (2022)** using lavender, Juniper and wild mint oils on *M. obstructa*. whom showed that these botanical oils have molluscicidal activity.

Table 2. Toxic effect of some tested botanical oils of *M. obstructa* adults using residual film technique

Oil	LC_{50} (mg/ml)	95% confidence limits Lower	upper	LC_{90} (mg/ml)	95% confidence limits Lower	upper	Slope±SE	Toxicity index (%) at LC_{50}	LC_{90}	Relative potency (fold) at LC_{50}	LC_{90}
Sweet basil	7.70	5.558	10.27	54.2	33.32	127.7	1.51± 0.24	100	64.3	3.49	4.42
Clove	8.18	6.397	10.29	36.0	25.43	62.05	1.99± 0.26	94.1	96.9	3.29	6.67
Peppermint	8.39	6.624	10.49	34.9	25.01	58.64	2.07± 0.27	91.8	100	3.21	6.88
Geranium	13.9	9.829	21.54	160	72.72	828.5	1.21± 0.23	55.4	21.8	1.94	1.50
Garlic	15.6	12.63	19.99	60.2	41.59	108.1	2.18± 0.28	49.3	57.9	1.72	3.99
Chamomile	26.9	18.79	48.49	240	104.5	1312	1.35± 0.25	28.6	14.5	1.0	1.00

LC_{50}: Concentration which is lethal to 50% of a population of test animals. LC_{90}: Concentration which is lethal to 90% of a population of test animals.

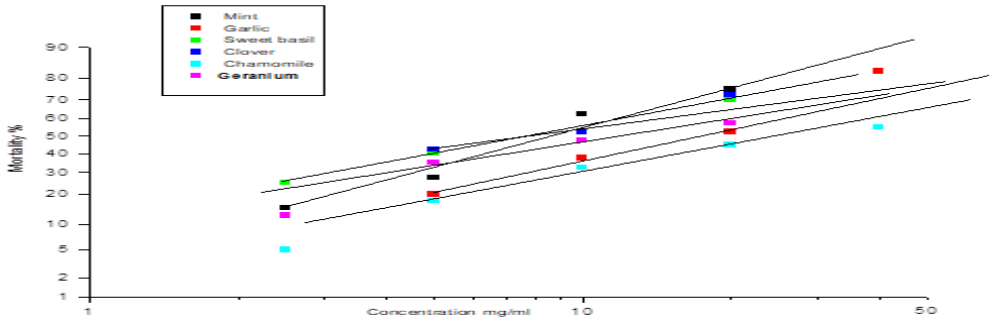

Fig. 2. Toxicity lines of essential oils by film method.

3.4. Antifeedant activity of the tested oils against *M. obstructa*

3.3.1. The inhibition rate

It is clear from Table 3 that the oil of sweet basil caused 82.4% inhibition in feeding activity at 4 mg/ml to the adult stage of *M. obstructa*. while the inhibition was 74.3% by garlic oil and 57.1%. by chamomile oil at the same concentration. The food consumption of the snail adult was 0.37 g at 4 mg/ml by sweet basil oil, thereby the feeding on lettuce leaves was less after 24 h of treatment and antifeeding effect was observed. Likewise, the food consumption was relatively greater by garlic and chamomile oils were 0.54 and 0.90 g at 4 mg/ml compared to 2.10 g in control. Apparently, chamomile oil was not given a positive percentage of inhibition in feeding activity for the snails at 0.25 mg/ml because the food consumed was more than control. Only 9.52 and 6.19% inhibition resulted from the feeding on lettuce leaves treated with garlic and sweet basil oils at 0.25 mg/ml.

Table 3. Effect of three botanical oils on inhibition rate as a percentage (%) in feeding activity to of *M. obstructa* adults

Concentration (mg/ml)	Mean weight after 24 h	Food consumption (g)	Inhibition (%)
	Sweet basil oil		
Control	2.90a	2.10	-
0.25	3.03a	1.97	6.19
0.50	3.27b	1.73	17.6
1.0	3.63c	1.37	34.8
2.0	4.20d	0.80	61.9
4.0	4.63e	0.37	82.4
LSD at 0.05	0.139	-	-
	Chamomile oil		
Control	2.90a	2.10	-
0.25	2.73b	2.27	-8.09
0.50	3.13c	1.87	10.9
1.0	3.46d	1.54	26.7
2.0	3.54 d	1.46	30.5
4.0	4.10 e	0.90	57.1
LSD at 0.05	0.131	-	-
	Garlic oil		
Control	2.90a	2.10	-
0.25	3.10 b	1.90	9.52
0.50	3.53c	1.47	30.0
1.0	3.80d	1.20	42.9
2.0	4.13e	0.87	58.6
4.0	4.46f	0.54	74.3
LSD at 0.05	0.135	-	-

The weigh before treatment was 5 g/disc of fresh lettuce leaves.

3.3.2. Inhibitory concentrations (IC_{50} and IC_{90})

The concentrations which cause 50 and 90% inhibition (IC_{50} and IC_{90}) in the feeding activity by snails are shown in Table 4. It was explained that of garlic oil was the most active as antifeedant with IC_{50} of 1.40 mg/ml followed by sweet basil with IC_{50} was 1.45 mg/ml. Based on IC_{90} value, sweet basil was more active on *M. obstructa* adults than garlic oil as feeding deterrent, the IC_{90} for sweet basil and garlic oils were 6.05 and 10.0 mg/ml respectively. The antifeedant activity decreased with chamomile oil with IC_{50} and IC_{90} of 2.78 and 14.6 mg/ml at IC_{50} level, chamomile was half the activity of garlic, and the relative potency was almost two folds as effective as chamomile. At IC_{90} level, sweet basil was 2.4 times more active than chamomile oil and the last one was 41.4 activity compared to sweet basil (100%). In contrast, clove, geranium, and peppermint oils failed to show any antifeeding action. botanical oils that acted as antifeedants against land snails was recorded on *Allium sativum* by **El-Zemity and Radwan (2001)** on *Artemisia herba-alba* and *Azadirachta indica* by **Afifi *et al.* (2007**), on *Lupinus termis* by **Azzam *et al.* (2014)**, on *Anagallis arvensis* by **Ali *et al.* (2020)** and on *Mentha longifolia* by **Abobakr *et al*. (2022)** who found that these natural plants contain oils which have powerful antifeedant properties.

Table 4. Antifeeding activity of three botanical oils against *M. obstructa* adults

Oil	IC_{50} (mg/ml)	95% confidence limits		Fold	Activity (%)	IC_{90} (mg/ml)	95% confidence limits		Fold	Activity (%)	Slope±SE	X^2
		Lower	upper				Lower	upper				
Sweet basil	1.45	1.258	1.686	1.92	96.6	6.05	4.658	8.598	2.41	100	0.293±0.066	2.062
Garlic	1.40	1.686	1.717	1.99	100	10.0	6.720	17.97	1.46	60.5	1.499±0.061	2.511
Chamomile	2.78	2.294	3.549	1.00	50.4	14.6	9.649	26.79	1.00	41.4	1.779±0.073	5.812

3.3.3. Identification of the chemical constituents in the essential oil of sweet basil using GC/MS analysis

Twenty essential oils were identified in sweet basil as listed in Table 5 and their chemical structures in Fig. 3. These oils were divided into twelve monoterpene hydrocarbons (70.83%) and eight sesquiterpene hydrocarbons (29.17%). It is evident that linalool (35.90%) was the most abundant compound followed by eucalyptol (12.73%) and α-farnesene (8.68%). Also, among the identified compounds were *β*-pinene (1.03%), estragole (7.59%), bornyl acetate (1.81%), eugenol (7.64%) and o-cymene (0.53%) that tracking monoterpene oils. Besides the identified essential oils which belong to sesquiterpenes such as γ-muurolene (5.42%), tau-candiol (4.50%), α-humulene (2.39%) and germacrene D (3.95%). It is worth noting in the current study that sweet basil oil exhibited strong molluscicidal and antifeedant activities against the adults of *M. obstructa*. This may be that the terpene hydrocarbons which included monoterpenes and sesquiterpenes found in the essential oil of sweet basil are responsible for causing this activity. These results are in agreement to the findings of **Salama *et al.* (2012)** reported that the major sesquiterpene hydrocarbon in essential oil of *Marrubium vulgare* was γ-cadinene (17.68%) while Z-caryophyllene was the major sesquiterpene hydrocarbon in essential oil of *Thymus capitatus* (6.15%). The two

plant oils appeared dominated by the oxygenated constituents, these were *mainly* composed of phenols among which carvacrol (32.98%) in *T. capitatus* and *thymol* (34.55%) in *M. vulgare*. Both oils showed promising molluscicidal activity against *Biomphalaria alexandrina* snails concluding that this activity may be attributed to thymol and carvacrol. **Gomes *et al*. (2019)** found that the major constituent is limonene (58.81%) as monoterpene and the minority component is α-mulene (0.11%) when extracted the oils from *Citrus limon* peels. Also, among the identified oils using GC/MS analysis were γ-terpinene (9.01%), sabinene (5.08%), *β*-pinene (4.91%) and α-citral (1.61%). The essential oil is highly toxicity to the adults of *Biomphalaria glabrata* snails than *Aedes aegypti* and not toxic to the larvae of *Artemid salina*. **Abobakr *et al.* (2022)** identified the chemical constituents from the essential oil (EO) of *Juniperus procera* and *Lavandula dentata*. Both tested plants exerted antifeedant and molluscicidal effects on *M. obstructa*. In the *J. procera*, five compounds were specified which represented 97.87% of the EO composition. The oil components were α-pinene (53.70%), P- cymene (24.83%), *β*-ocimene (10.78%), γ-elemene (5.25%) and thymol (3.31%). Camphor (45.74%) was the most abundant compound in *L. dentata* followed by eucalyptol (18.63%) and *β*-myrcene (9.02%). However, additional research is needed to evaluate the tested botanical oils as molluscicides against the terrestrial snails under field conditions and testing pure separated oils such as monoterpenes which represent 70.83% of the total oils in sweet basil to know it's combat efficiency on snails.

Table 5. Chemical constituents identified from the essential oil of sweet basil

NO	Essential oil	Molecular formula	Molecular weight	RT (min)	Area (%)
		Monoterpenes			
1	α-pinene	$C_{10}H_{16}$	136.23	6.30	1.07
2	Camphene	$C_{10}H_{16}$	136.23	6.66	0.26
3	*β*-pinene	$C_{10}H_{16}$	136.23	7.18	1.03
4	o-cymene	$C_{10}H_{14}$	134.22	7.35	0.53
5	Eucalyptol	$C_{10}H_{18}O$	154.25	7.44	12.73
6	*β*-ocimene	$C_{10}H_{16}$	136.23	8.25	0.62
7	Linalool	$C_{10}H_{18}O$	154.25	8.74	35.90
8	Estragole	$C_{10}H_{12}O$	148.20	10.10	7.59
9	α-terpineol	$C_{10}H_{18}O$	154.25	10.44	1.33
10	Sabinene	$C_{10}H_{16}$	136.23	11.43	0.32
11	Bornyl acetate	$C_{12}H_{20}O_2$	196.28	11.79	1.81
12	Eugenol	$C_{10}H_{12}O_2$	164.20	12.65	7.64
		Sesquiterpenes			
13	γ-Elemene	$C_{15}H_{24}$	204.35	12.81	0.40
14	α-cubebene	$C_{15}H_{24}$	204.35	13.12	1.01
15	α-farnesene	$C_{15}H_{24}$	204.35	13.58	8.68
16	α-humulene	$C_{15}H_{24}$	204.35	14.02	2.39
17	Germacrene D	$C_{15}H_{24}$	204.35	14.20	3.95
18	γ-muurolene	$C_{15}H_{24}$	204.35	14.53	5.42
19	*β*-guaiene	$C_{15}H_{24}$	204.35	16.41	2.82
20	Tau-cadinol	$C_{15}H_{26}o$	222.37	16.17	4.50
Total identified essential oils					100
Total monoterpene hydrocarbons					70.83
Total sesquiterpene hydrocarbons					29.17

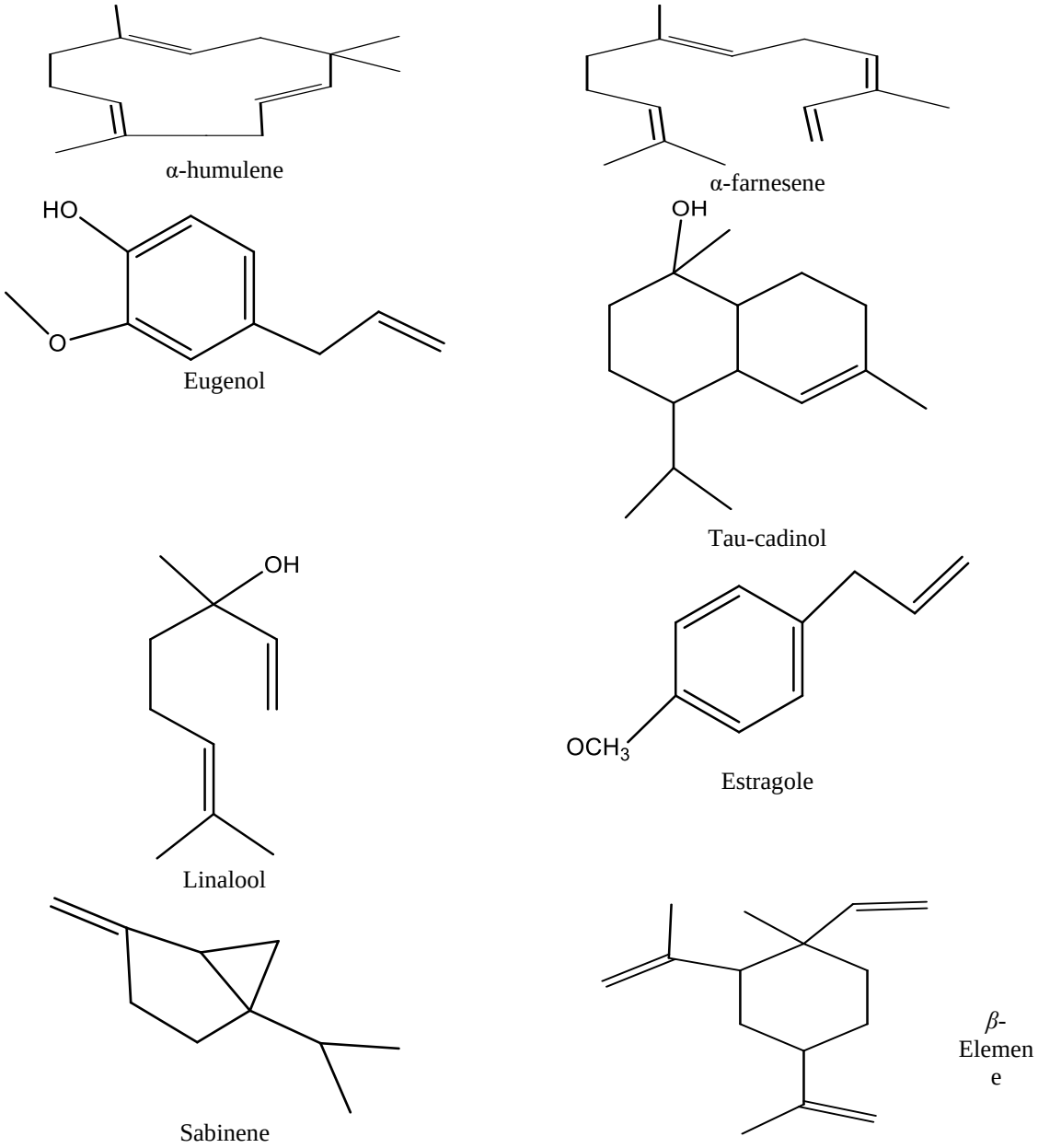

Fig. 3. The chemical structures of terpenes from sweet basil.

4. CONCLUSION

These results indicated that sweet basil oil was the most toxic using contact and spray methods. Also, the same oil caused highly inhibition infeeding activity to the land snail *M. obstruct*. Moreover, 20 essential oils were identified in sweet basil, linalool was the most

abundant oil (35.9%). Therefore, sweet basil oil can be exploited as molluscicide or as antifeedant

REFERENCES

Abbott, W. S. 1925. A method of computing the effectiveness of an insecticide. J. Econ. Entomol., 18:265-267.

Abdel-Rahman, A. H. E. 2020. Usage of some botanical oils to control the land snail *Monach sp* (gastropoda: helicidae). Egypt J. Plant Prot. Res. Inst., 3(4):1241-1245.

Abdel-Rahman, A. H. E. 2017. Efficiency of some natural plant extracts and ferrous sulphate in controlling the land snail (*Monacha cartusiona*) under laboratory and field conditions at Sharkia governorate, Egypt. J. Plant Prot. and path. Mansoura Univ., 8(12):647-650.

Abobakr, Y., Al-Sarar, A. S. and Abd El-Kader, M. S. 2022. Fumigant toxicity and feeding deterrent activity of essential oils from *Lavandula dentate*, *Juniperus procera* and *Mentha longifolia* against the land snail *Monacha obstructa*. J. Agric. Sci., 12(7):934-943.

Afifi, M. A., Ibrahim, N. M., El-Sisi, A. G. and Soheir, A. M. 2007. Toxicology studies of some plant extracts against glassy clover snail *Monacha obstracta (*Plitter). J. Agric. Sci. Mansoura Univ., 32(6):4861-4869.

Ali, I. H. H., Abd El-Halim, S. M., Mohamed, R. F. A. and El-Sayed, SH. A. M. 2020. Molluscicidal and antifeedant impacts of some weed extracts on the land snail *Monacha obstructa* (pfeiffer). Fayoum J. Agric. Res. Dev., 34(2):204-217.

Ascher, R. S. and Marian, F. 1981. The residual contact toxicity of BAY SIR 8514 to *spodoptera littoralis* larvae. Phytoparasitica, 9(2):133-137.

Azzam, K. M., El-Razek, E. A. and Metwally, F. 2014. Effect of ethanolic lupine seed extract on aquatic and terrestrial snails. Egyptian J. Biol. Pest Control, 24(1):151-155.

Barratt, B. I., Lorimer, S. D., Perry, N. B., Foster, L. M. and Ferguson, C. M. 1993. A bioassay to evaluate native plant extracts as slug feeding deterrents. Proc. 46th N.Z. Plant Protection Conf., pp 194-196.

El-Zemity, S. R. and Radwan, M. A. 2001. Molluscidal and antifeedant activity of some essential oils and their major chemical constituents against *Theba pisana* snails. Arab Univ. J. Agric. Sci., 9:483-493.

Eshra, E. H. 2014. Toxicity of methomyl, copper hydroxide and urea fertilizer on some land snails. Ann. Agric. Sci., 59(2):281-284

Farag, M. F. and Sabry, H. M. 2017. Laboratory and field studies for evaluation of some fresh and used plant oils on the glassy clover snail, *Monacha cartusiana* (Muller). Egypt J. Agric. Res., 95(4):1563-1577.

Finney, D. J. 1971. Probit analysis, London: Cambridge university press, pp 318.

Gomes, P. R., Oliveira, M. B., Fernandes, R. P., Louzeiro, H. C., Filho, V. EandFontenele, M. A. 2019. Larvicidal activity, molluscicide and toxicity of the essential oil of citrus limon peels against *Aedes agypti*, *Biomphalaria glabrata* and *Artemia salina*. Eclética Química, 44(4):85-95.

Gunther, E. 1948. The essential oils: History and origin in plants production

analysis. Krieger publishing, New York, 235-240.

Idris, H., Gustia, H. and Ramadhan, A. H. 2020. The potential of essential oils as botanical molluscicide for controlling golden apple snail *(Pomacea canaliculata,* Lamarck) in Indonesia. J. Crit. Rev., 7(13): 946-952.

Ismail, S. A. A., Shetala, S. Z. S., Arafa, A. I. and Abd El-Atty, S. F. 2011. Incidence and seasonal fluctuation of certain land gastropod species associated with some crops and weeds at Sharkia Governorate. J. Plant Prot. Path., Mansoura Univ., 2(12):1103-1110

Mesbah, H. A. N., Mourad, A. K., Eshra, H. E. and El-Zaroug, R. 2022. Efficiency of two phytochemical compounds and a biopreparation against the common prevailing land snail species in Alexandria governorate, J. Adv. Agric. Res., 27(4):703-709.

Mourad, A. A. 2014. Molluscicidal effect of some plant extracts against two land snail species, *Monacha obstructa* and *Eobania vermiculata.* Egypt Acad. Biol. Sci., 6(1):11-16.

Nakhla, J. M., Tadros, A. W. and El-Hwashy, N. 2002. Monitoring the changes in the population activity of *Monacha obstructa* in Apple orchards and Egyptian clover fields in Giza governorate. Egypt J. Agric. Res., 80(1):181-188.

Saad, M. G and Abou-Taleb, H. K. 2015. chemical composition fumigant toxicity and biochemical effects of essential oils on *Spodoptera littoralis* (Lepidoptera: Noctuidae) and *Theba pisana* (mollusca: Gastropoda:Helicidae). Egypt J. Plant Pro. Res., 3(1):1-20.

Salama, M. M., Taher, E. E. and El Bahy, M. M. 2012. Molluscicidal and Mosquitocidal activities of the essential oils of *Thymus capitatus* L. and *Marrubium vulgare* L. Am. J. Drug Disc. Devel., 2(4):204-211.

Shoaib, M. A., Mahmoud, M. F., Loutfy, N., Tawfic, M. A. and Barta, M. 2010. Effect of botanical insecticide Nimbecidine® on food consumption and egg hatchability of the terrestrial snail *Monacha obstructa*. J. Pest Sci., 83:27-32.

Snedecor, G. W. and Cochrane, W. G. 1980. Statistical methods. 7thEd., Iowa state Univ. press, Ames, USA.