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Effect of Some Plant Extracts on *Mentha longifolia*, *Lavandula officinalis* and *Mentha piperita*

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ABSTRACT

This study was carried out during two successive seasons (2020/2021and 2021/2022). It included three experiments, First Experiment: Effect of ginger extract (0, 2, 4, 6 and 8 mg/l) on *Mentha longifolia*, Second Experiment: Effect of neem extract (0, 1, 2, 3 and 4 mg/l) on *Lavandula officinalis* and Third Experiment: Effect of garlic extract (0, 1.5, 3, 4.5 and 6 mg/l) on *Mentha piperita*. The results indicated that these extracts had a pronounced effect on all traits under study. The main components of lavender essential oil were camphor, linalool and eucalyptol. Menthol, menthone and menthyl acetate were the major components of *Mentha piperita*. Moreover the main constituents of *Mentha longifolia* were Cis-piperitone oxide, Pulegone and Piperitenone.

Keywords: *Mentha longifolia, Lavandula officinalis, Mentha piperita*, ginger, neem, garlic

1. Introduction

The use of inorganic fertilizers by farmers and their high cost is further associated with land and soil degradation and environmental pollution. Thus, effort is being made to provide alternative safe natural sources of plant nutrients. For avoiding the excessive use of chemical fertilizers, some natural sources are used such as algae and plants extracts could be replace partially or completely the aforesaid harmful ones. So, recently, a great attention is focused on the possibility of using natural and safe agents for promoting growth and yield of crops.

Genus of Lavandula (Lamiaceae) consists of about 20 species as mentioned by Djamila *et al.* (2022). Boelens, (1995) reported that Lavender is the most useful medicinal plants where its essential oil is widely used in colognes, soap, and other cosmetics as mentioned by Paul *et al.*, (2004). Silva *et al.* (2023) noticed that Lavandula essential oil is used as relaxant anti-inflammatory and antiseptic agent and scabies and headaches treatment.

Mentha longifolia L. (wild mint) belongs to Lamiaceae family grows in Mediterranean regions, Europe, Australia and North Africa (Harley and Brighton 1977). Mikaili *et al*. (2013) reported that *M. longifolia* is used widely in food, tobacco, cosmetics and pharmaceutical industries. Different parts of the plant have been used in traditional folk medicine and treatment of various diseases. *Mentha piperita* (peppermint), is one of the most important essential oil plants. Camele *et al.* (2021) reported that the main constituent of its essential oil is menthol followed by menthone which is used in pharmaceutical, cosmetic, food, perfumery and flavor industries besides aromatherapy. The yield and quality of cultivated plants are affected by various factors such as the climate and soil factors, the genetic potential of the plant and many other agronomic practices as mentioned by Noroozlo *et al.* (2019); *Souri et al.* (2019) and Chaski *et al.* (2023).

Garlic, belongs to Liliaceae family (Ahmad, 2021), has a very strong pungent smell and it contains an essential oil where its main compounds are sulphur such as aliin, allicin etc. (El-Saber Batiha *et al.*, 2020). Ginger (*Zingiber officinale*) is a perennial and rhizome producing plant that contains resins and a volatile oil as mentioned by Mahboubi, (2019). It has a pungent and aromatic smell, and these properties make extracts from plants an important biochemical for growth and production.

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Neem (*Azadirachta indica*) has great importance due to its numerous applications in cosmetics and medicine as reported by Subapriya and Nagini (2005), Naz *et al.* (2022). Rahmani *et al.* (2018) mentioned that azadirachtin is the most active compound. Leaves of Neem contain active compounds such as amino acids, ascorbic acid, nimbin and nimbolide etc. as reported by Rodrigues *et al.* (2012) and Sarah *et al.* (2019). Quercetin and ß-sitosterol as polyphenolic compounds are extracted from leaves of neem (Alzohairy, 2016).

This study aimed to evaluate the effect of some plant extracts on the herb weight and essential oil yield and chemical composition of *Mentha longifolia*, *Lavandula officinalis* and *Mentha piperita*.

2. Materials and Methods

2.1. Preparation of plant extracts

Garlic extract was carried out with water according to Wanas *et al.* (2018). The extracts of ginger (rhizome) neem (leaves), were prepared by grinding the selected part of plant in distilled water. The extracts collected were centrifuged for 5 min. & supernatant was collected.

2.2. Phytochemical screening

The presence of phytochemicals such as saponins alkaloids, tannins, phenols, flavonoids, glycosides and steroids was estimated in the aqueous extracts according to the procedures and methods of Trease and Evans (1989), Soforowa (1993) and Harbone (1994) as described by Ameh and Eze (2010). The presence of amino acids and proteins was estimated according to Boxi *et al.* (2010).

2.3. Field experiments

Three experiments were conducted under a greenhouse of National Research Centre conditions, Egypt, through two seasons (2020/2021, 2021/2022). *Mentha longifolia*, *Mentha piperita* and *lavandula officinalis* plants were transported from Medicinal and Aromatic Plants Institute (IMAP), Egypt. Uniform plantlets were cultivated into clay pots No30 cm at the 1st week of March (2020 and 2021). Three weeks after cultivation, the plantlets were thinned to three per pot.

After 30 days, *Mentha longifolia* plants were sprayed with ginger extract (0, 2, 4, 6 and 8 mg/l), *Lavandula officinalis* were sprayed with neem extract (0, 1, 2, 3 and 4 mg/L) and *Mentha piperita* were sprayed with garlic extract (0, 1.5, 3, 4.5 and 6 mg/L). These treatments were repeated monthly and the untreated plants were sprayed with water.

The plants were harvested after 3 months from cultivation as 1st cut and the 2nd one after 3months later during both seasons vegetative growth parameters were recorded such as fresh and dry weight of herb (g/plant).

2.4. Essential oil extraction

Essential oil isolation: About 100g of herbs were harvested from each replicate and subjected to hydro-distillation for 3h using a Clevenger apparatus (Clevenger, 1928). Total essential oil yield (ml / plant) was calculated.

2.5. GC-MS analysis

To identify essential oil constituents was carried out by GC-MS system (Agilent Technologies) equipped with gas chromatograph (7890B) and mass spectrometer detector (5977A) at National Research Centre.

2.6. Statistical analysis

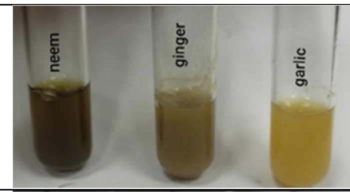
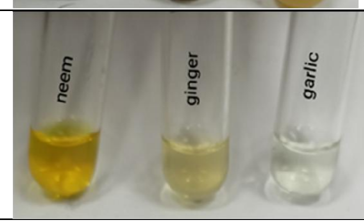
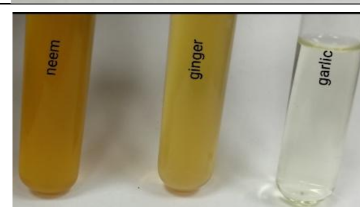
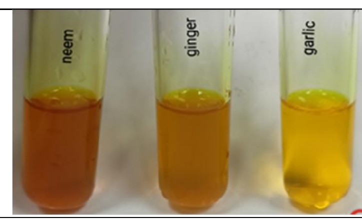
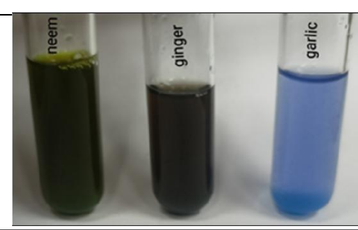
A complete random block design was used where. The averages data of both seasons were statistically analyzed according to Snedecor and Cochran (1994). Duncan's multiple range tests were used to compare mean differences at 0.5 according to Duncan (1955).

3. Results and Discussion

3.1. Phytochemical screening results

The results of phytochemical screening of the aqueous extracts of garlic, ginger and neem are presented in Table (1). Data in this table shows that saponins were present in high quantity in garlic and neem extracts, while it was present in moderate quantity in ginger extract. Tannins, flavonoids and glycosides were present in high quantity in neem extract and moderate quantity in ginger extract. Alkaloids were present in low quantity in both ginger and neem extracts, while it was absent in garlic extract. Also, tannins, phenols and steroids were absent in garlic extract, while proteins and amino acids were present in high quantity. The obtained results are similar to those previously reported by Arify *et al*. (2018), Osabor *et al.* (2015) and Ujah *et al.* (2021) for the aqious extracts of garlic, ginger and neem, respectively.

Table 1: Qualitative phytochemical analysis of garlic, ginger and neem extracts

Components	Ginger	Neem	Garlic	images
Saponins	+ +	+ + +	+ + +	
Alkaloids	+	+	-	
Tannins	+ +	+ + +	-	
Phenols	+	++	-	
Flavonoids	+ +	+ + +	+	
Glycosides	+ +	+ + +	+	
Steroids	+	+ +	-	
Proteins	+	+	+++	

3.2. Effect of ginger extract on *Mentha longifolia*

Data tabulated in Table (2) suggest that ginger extract levels had a significant effect on fresh and dry weights compared with untreated plants during both cuts. Furthermore, ginger extract at 6mg/L gave the maximum mean values of fresh (274.1 and 285.9 g/plant) and dry weights (96.2 and 98.5g/plant) followed by 4 mg/L during both seasons.

The highest mean values of essential percentage (0.5 and 0.4%) were obtained as a result of ginger extract at 6.0 mg/L followed by 4 and 2 mg /L (0.4%) for the 1st cut and 4 mg/L (0.3%) for the 2nd one.

Concerning the effect of ginger extract levels on essential oil yield, it can be noticed that ginger extracts at 2, 4 and 6 gave a pronounced effect on essential oil yield which recorded 0.4, 0.3 and 0.5 ml/ plant during 1st cut, respectively compared with 0 and 8 mg/L which recorded 0.1 ml/plant. In the 2nd cut 0, 2 and 8 mg/L gave the same value of essential oil yield (0.1 ml/plant) while ginger extract at 4 and 6 mg/L gave 0.2 and 0.4 ml/ plant.

Table 2: Effects of ginger extract on herb weight and essential oil yield of *Mentha longifolia*

Treatments (mg/L)	First harvest				Second harvest			
	Herb weights (g/pant)		Essential oil		Herb weights (g/pant)		Essential oil	
	Fresh	Dry	%	g/plant	Fresh	Dry	%	g/plant
0	188.3^{e}	43.7^{d}	0.2^{d}	0.1^{d}	164.3^{e}	49.6^{d}	0.1^{d}	0.1^{c}
2	194.2^{d}	55.8^{c}	0.4^{b}	0.4^{b}	205.7^{d}	56.2^{c}	0.2^{c}	0.1^{c}
4	237.3^{b}	77.3^{b}	0.4^{a}	0.3^{c}	242.7^{b}	77.9^{b}	0.3^{b}	0.2^{b}
6	274.1^{a}	96.2^{a}	0.5^{a}	0.5^{a}	285.9^{a}	98.5^{a}	0.4^{a}	0.4^{a}
8	198.4^{c}	41.3^{e}	0.3^{c}	0.1^{d}	220.1^{c}	44.1^{e}	0.2^{c}	0.1^{c}

Means followed by similar letter(s) within the same column are no significantly different at $P \leq 0.05$ according to Duncan's Multiple Range Test.

Data presented in Table (3) show that total main constituents ranged from 75.95 to 98.15% where the highest total relative percentage (98.15%) was obtained from plants treated by ginger extract at 0 to 8 mg/L. The major compounds were cis-piperitenon oxide (29.11- 35.62%), pulegone (20.64 – 33.98%), piperitenone (10.02-12.05), 1, 8-cineol (6.33-8.34%), p-piperitone (2.05-4.10%) and menthone (1.02-9.33%). Essential oil obtained from plants treated with 8.0 mg/L gave the maximum relative percentage of pulegone (33.98%), piperitenone (12.05%), 1, 8-cineol (8.34%), p-piperitone (4.10%) and menthone (9.33%). On the other hand, plants treated with ginger extract at 4.0 mg/L gave the maximum relative percentage of cis-piperitenon oxide (35.62%). Shahdadi *et al.* (2021) reported that the major compounds in the essential oil were piperitenone oxide, pulegone, piperitenone, and 1, 8-cineole which calculated 26.07%, 19.72%, 11.88% and 8.21%, respectively that can play a very important role in its antimicrobial activity. Moreover, Shahdadi *et al.* (2023) found that pulegone (26.07%), piperitone oxide (19.72%), and piperitone (11.88%) were the major components of *M. longifolia* oil.

Table 3: Effect of Ginger extract on major main essential oil constituents of *Mentha longifolia* (mean relative percentage of two cuts during 2nd season)

Constituents	0	2.0	4.0	6.0	8.0
α-Pinene	0.01	0.02	0.01	0.02	0.03
Sabinene	0.12	0.11	0.11	0.12	0.12
β-Pinene	0.78	0.77	0.69	0.82	0.80
1,8-Cineol	6.33	6.99	7.84	8.19	8.34
Menthone	1.02	1.02	4.03	5.03	9.33
Iso-pulegone	0.11	0.22	0.29	0.28	0.29
Cis-piperitone oxide	34.02	33.03	35.62	30.04	29.11
Pulegone	24.01	20.64	24.57	31.93	33.98
Piperitenone	10.05	10.02	11.08	11.07	12.05
piperitone	2.05	3.13	3.12	4.03	4.10
Total	78.5	75.95	87.36	91.53	98.15

3.3. Effect of neem extract on lavender

The impact of neem at different concentrations on lavender plants are presented in Table (3). Results in this table reveal that neem extract levels increased the fresh and dry weights of lavender herb compared with untreated plants during both cuts. During 1st cut neem extract at 2.0 mg/L gave the highest mean values of fresh and dry weights (142.2 and 54.6 g/plant) followed by 3.0 mg /l which produced 47.3 g/plant. Also, in the 2nd cut neem extract at 2.0 mg/l resulted in the maximum value of fresh and dry weights (156.7 and 58.6 g/plant) followed by 1.0 mg/L which recorded 128.9 and 45.8 g/plant.

Data presented in Table (4) indicated that there is no considerable variation for essential oil % as a result of neem extracts application during both cuts where the maximum value of essential oil% (1.7 and 1.6%). Moreover, essential oil yield reached to its maximum value (0.9 ml/plant) as a result of neem extract application at 2.0 mg/L.

Table 4: Effect of neem extracts on herb weight and essential oil yield of lavender

Treatments (mg/ L)	First harvest				Second harvest			
	Herb weights (g/pant)		Essential oil		Herb weights (g/pant)		Essential oil	
	Fresh	Dry	%	g/plant	Fresh	Dry	%	g/plant
0.0	78.8[e]	22.1[e]	1.2[c]	0.3[e]	88.1[e]	25.6[e]	1.1[c]	0.3[e]
1.0	120.1[c]	43.2[c]	1.3[bc]	0.6[c]	128.9[b]	45.8[b]	1.4[b]	0.6[b]
2.0	142.2[a]	54.6[a]	1.7[a]	0.9[a]	156.7[a]	58.6[a]	1.6[a]	0.9[a]
3.0	127.8[b]	47.3[b]	1.4[b]	0.7[b]	117.8[c]	41.1[c]	1.3[b]	0.5[c]
4.0	116.1[d]	33.3[d]	1.3[bc]	0.4[d]	112.5[d]	29.3[d]	1.2[c]	0.4[d]

Means followed by similar letter(s) within the same column are no significantly different at $P \leq 0.05$ according to Duncan's Multiple Range Test.

Data tabulated in Table (5) identified (15) main compounds from lavender essential oil produced from plants treated with different doses of neem extract. It is clear that camphor compound recorded the highest values (24.06, 22.10, 23.63, 22.54 and 42.01%) when plants treated with neem extract at 0, 1, 2, 3 and 4 mg / l, respectively followed by linalool compound which recorded 15.53, 16.07, 16.23, 17.03and 17.13%. The third one was eucalyptol which gave the maximum relative percentage (26.24%) as a result of neem extract at 1 mg/L.

Table 5: Effect of Neem extract on major main essential oil constituents of *Lavandula officinalis*

Constituents	Control	1	2	3	4
alpha-Pinene	0.87	5.96	5.61	6.43	5.94
Camphene	0.63	1.28	1.29	1.36	1.36
D-Limonene	1.55	1.78	1.99	1.98	2.12
Linalyl propionate	1.22	1.2	1.33	1.33	1.35
Eucalyptol	11.32	13.57	12.01	12.48	13.33
Linalool	15.53	16.07	16.23	17.03	17.13
Lavandulol	2.05	1.99	2.13	2.15	2.18
Camphor	24.06	22.1	23.36	22.54	24.01
endo-Borneol	1.07	0.84	0.98	1.02	1.00
Terpinen-4-ol	6.75	7.39	7.64	7.84	8.31
p-menth-1-en-8-ol	2.29	2.13	2,66	3.01	3.23
Linalyl acetate	10.04	11.12	12.03	12.31	12.3
Nerol acetate	4.35	5.36	5.77	5.78	5.76
Caryophyllene	0.29	0.27	0.27	0.28	0.36
Caryophyllene oxide	1.36	1.14	1.23	1.15	1.44
Total identified	83.38	92.2	91.87	96.69	99.82

In this connection Alname *et al.*, (2011) and Slimani *et al.*, (2022) found that the main constituents of lavender were linalool, linalool acetate, 1.8-cineole and camphor which recorded 44.67, 42, 5.30 and 5.30, respectively. Talbaoui *et al.*, (2012) reported that, linalyl acetate (44.96%) and linalool (44.64%) are the major constituents of lavender essential oil. Diass *et al.*, (2023) found that the main components were linalool, camphor linalyl acetate and eucalyptol which recorded 14.93%, 14.11, 11.17 and 10.99, respectively.

The promotive effect of Neem leaves extract may be due to this extract contains different chemicals like amino acids and ascorbic acid, etc. (Alzohairy, 2016).

3.3. Effect of garlic extract on peppermint

The obtained data in Table (6) revealed that the application of garlic extracts increased the fresh and dry weights of peppermint herb compared with untreated plants. The highest values of fresh and dry weights were obtained from plants treated with garlic extract at 4.5 mg/L followed by 3 mg/L. Concerning the effect of garlic extracts on essential oil percentage and yield (ml/plant), it can be observed that, garlic extract at 4.5 mg/L gave the maximum values of oil percentage and yield (ml/plant) during both cuts.

Table 6: Effect of garlic extracts on herb weight and essential oil yield of peppermint

Treatments (mg/ L)	First harvest				Second harvest			
	Herb weights (g/pant)		Essential oil		Herb weights (g/pant)		Essential oil	
	Fresh	Dry	%	g/plant	Fresh	Dry	%	g/plant
0.0	72.8^{e}	20.6^{d}	0.4^{c}	0.1^{b}	86.1^{e}	20.4^{d}	0.5^{d}	0.1^{d}
1.5	149.2^{d}	26.7^{c}	0.5^{c}	0.1^{b}	161.6^{c}	32.5^{b}	0.6^{c}	0.2^{c}
3.0	161.8^{b}	29.8^{b}	0.7^{b}	0.2^{b}	176.2^{b}	33.2^{b}	0.8^{b}	0.3^{b}
4.5	282.7^{a}	38.9^{a}	1.1^{a}	0.4^{a}	299.5^{a}	43.9^{a}	1.2^{a}	0.5^{a}
6.0	158.8^{c}	27.8^{c}	0.8^{b}	0.2^{b}	157.8^{d}	26.5^{c}	0.7^{b}	0.2^{c}

Means followed by similar letter(s) within the same column are no significantly different at $P \leq 0.05$ according to Duncan's Multiple Range Test.

Data tabulated in Table (7) identified (10) main compounds from peppermint essential oil produced from plants treated with different doses of garlic extract. It is clear that the compound of menthol recorded the highest values (28.33, 28.35, 30.63, 31.55 and 30.22%) when plants treated with garlic extract at 0, 1.5, 3, 4.5 and 6 mg/L, respectively followed by menthone compound which recorded 20.07, 23.33, 28.05, 30.26 and 29.53%. The third one was Menthyl acetate which gave the maximum relative percentage (26.24%) as a result of garlic extract at 6 mg/L.

Table 7: Effect of Garlic extract on major main essential oil constituents of *Mentha piperita*

Constituents	Control	1.5	3	4.5	6
alpha.-Pinene	0.28	0.73	0.48	0.46	0.6
Sabinene	0	0.39	0	0.17	0.17
(-)-beta-Pinene	0.53	1.11	0.81	0.83	0.99
Limonene	3.01	3.12	3.27	3.36	3.39
Eucalyptol	2.86	5.6	6. 97	4.4	5.35
Menthone	20.07	23.33	28.05	30.26	29.53
Menthol	28.33	28.35	30.63	31.55	30.22
Iso-Menthone	0.81	0.81	0.92	0.98	1.36
Menthyl acetate	22.06	21.6	23.23	25.36	26.24
Caryophyllene	0.87	2.13	1.83	1.45	1.41
Total identifird	78.82	87.17	89.22	98.82	99.26

Similarly, de Oliveira Hashimoto *et al.* (2016) and Malheiros *et al.* (2016) mentioned that menthol is the major component of the essential oil of this plant. In contrast, Laghouiter *et al.,* (2015) found that trans-carveol (58.98%), D-limonene (19.94%), carvone (2.07%), and 4-terpineol (3.01%) are the major components of pepermint under South Algeria condition. Under Iran conditions, Yadegarinia *et al*., (2006) showed that a-terpinene (19.7%), isomenthone (10.3%), trans-carveol (14.5%), piperitenone oxide (19.3%) and β-caryophyllene (7.6%) are the main components of piperment essential oil.

The promotive effect of the above extracts may be due to these extracts contains various compounds, a number of which accumulated in large amounts, which most vital of them are triterpene, phenolic as well as flavonoid compounds. Additionally, these extracts contain protein, amino acid, monosaccharide, tannins, lignins, starch, phytosterols, choline, different types of vitamins i.e. B1, B2, B3, B6, C, E, biotin, folic acid, pantothenic acid, many minerals (Al, Ca, Fe, Mg, Co, Zn, P, Na, Si, K and Sn) as well as bitter principles, sulpher compounds. Also, these extracts may contains some compounds, which have similar effect to that of growth promoters, a wide range of minerals, amino acids, vitamins and in addition carbohydrate and nitrogen (Osabor *et al.*, 2015; Arify *et al*., 2018; Ujah *et al.,*2021).

According to the previous studies in this context, foliar application of such extracts could accelerate the growth of receiver plants via several mechanisms. Among these mechanisms, it could stimulate the photosynthesis of pigments, soluble sugars, nitrogen and volatile oil content (Shabana *et al.*, 2017; Slattery *et al.,* 2017). Also, the bio-elicitation of antioxidant enzymes such as superoxide dismutase and peroxidase, which maintain the balance of redox reactions products and prim the defense system of the plants, is another fundamental mechanics (Ali *et al.*, 2019). Moreover, it could promote the root growth, facilitating the nutrients uptake from the rhizosphere (Hayat *et al*., 2018).

4. Conclusion

The results revealed foliar spray and fertigation with the aqueous extract of ginger, neem and garlic stimulate the fresh and dry weight and oil content of the receiver plants. The obtained data offer ginger, neem and garlic extracts as innovative bio-fertilizers for commercial application in Lavander and mint plants. They could also be utilized as bio-fertilizers in other medicinal plants, however further investigations is required in the area of essential oil composition.

References

Ahmad, R.A.H., 2021. The effect of usage two methods of garlic extraction (foliar and ground application) on the growth of the tomatoes (*Solanum lycopersicum*) plant. In. J. Physics: Conference Series, 1879(2). 022021. IOP Publishing.

Ali M., Z. H. Cheng, S. Hayat, H. Ahmad, M. I .Ghani and L.I.U. Tao, 2019. Foliar spraying of aqueous garlic bulb extract stimulates growth and antioxidant enzyme activity in eggplant (*Solanum melongena* L.). J. Integr. Agric., 18(5): 1001-1013.

Alnamer, R., K. Alaoui, E. Houcine Bouidida, A. Benjouad, and Y. Cherrah, 2011. Toxicity and psychotropic activity of essential oils of *Rosmarinus officinalis* and *Lavandula officinalis* from Morocco. J. Biol. Active Prod. Nature, 1(4): 262-272.

Alzohairy, M.A., 2016. Therapeutics role of *Azadirachta indica* (Neem) and their active constituents in diseases prevention and treatment. Evid Based Complement Alternat. Med., 2016.

Ameh G.I. and C. S. Eze, 2010. Phytochemical constituents of some Nigerian plants. Bio-Research, 8(1): 614 – 617.

Arify T., S. Ezhilvalavan, A. Varun, A. Sundaresan, and K. Manimaran, 2018. Qualitative phytochemical analysis of garlic (*Allium sativum*) and nilavembu (*Andrographis paniculata*). Int J Chem Stud, 6(3): 1635-1638.

Boelens, M.H., 1995. Chemical and sensory evaluation of Lavandula oils. Perfum. flavor, 20: 23-23.

Boxi, M., Y. Rajesh, Raja, V., Kumar B., Praveen, K. Mangamma, 2010. Extraction, phytochemical screening and in-vitro evaluation of anti-oxidant properties of *Commicarpus chinesis* (aqueous leaf extract). Int. J. Pharm. Biosci. 1: 537–547.

Camele, I., Gruľová, D., & Elshafie, H. S. (2021). Chemical composition and antimicrobial properties of Mentha× piperita cv.'Kristinka'essential oil. Plants, 10(8): 1567.

Chaski, C., K.D. Giannoulis, A.A. Alexopoulos, and S.A. Petropoulos, 2023. Biostimulant Application Alleviates the Negative Effects of Deficit Irrigation and Improves Growth Performance, Essential Oil Yield and Water-Use Efficiency of Mint Crop. Agron., 13(8): 2182.

Clevenger, J.F., 1928. Apparatus for the determination of volatile oil. J. Am. Pharm. Assoc., (1912), 17(4): 345-349.

de Oliveira Hashimoto, G.S., F.M., Neto, M.L. Ruiz, M. Acchile, E. C. Chagas, F.C.M. Chaves and M.L. Martins, 2016. Essential oils of *Lippia sidoides* and *Mentha piperita* against monogenean parasites and their influence on the hematology of Nile tilapia. Aquac.450, 182-186.

Diass, K., M. Merzouki, K. Elfazazi, H. Azzouzi, A. Challioui, K. Azzaoui, and L. Rhazi, 2023. Essential Oil of *Lavandula officinalis*: Chemical Composition and Antibacterial Activities. Plants, 12(7): 1571.

Djamila, M., B. Nahla, A.A. Arezki, A. Fatma, A. Abdelkader, and B.A. Reda, 2022. Phytochemicals and Antimicrobial Activity of *Lavandula officinalis* Leaves Against Some Pathogenic Microorganisms. Egypt. Acad. J. Biol. Sci., C., Physiol. Mol. Biol., 14(2): 517-522.

Duncan D.B. Multiple range and multiple F-test. Biometrics 1955; 11:1–5.

El-Saber Batiha, G., A. Magdy Beshbishy, G.L. Wasef, Y.H. Elewa, A.A. Al-Sagan, M.E. Abd El-Hack, and H. Prasad Devkota, 2020. Chemical constituents and pharmacological activities of garlic (*Allium sativum* L.): A review. Nutrients, 12(3): 872.

Harbone, N.V. (1994). Phytochemical methods. A guide to modern techniques of plant analysis. 2nd ed. Chapman and Hall, London. 425.

Harley, R.M., and C.A. Brighton, 1977. Chromosome numbers in the genus Mentha L. Bot. J. Linn. Soc., 74(1), 71-96.

Hayat S., H. Ahmad, M. Ali, K. Hayat, M.A. Khan, and Z. Cheng, 2018. Aqueous garlic extract as a plant biostimulant enhances physiology, improves crop quality and metabolite abundance, and primes the defense responses of receiver plants. Appl. Sci, 8(9): 1505.

Laghouiter, O.K., A. Gherib, and H. Laghouiter, 2015. Study of the antioxidant activity of essential oils from some cultivated mints in the region of Ghardaïa. El Wahat Review for Research and Studies, 1: 84-93.

Mahboubi, M., 2019. *Zingiber officinale* Rosc. essential oil, a review on its composition and bioactivity. Clin. Phytoscience, 5(1), 1-12.

Malheiros, D.F., P.O. Maciel, M.N. Videira, and M. Tavares-Dias, 2016. Toxicity of the essential oil of *Mentha piperita* in *Arapaima gigas* (pirarucu) and antiparasitic effects on Dawestrema spp.(Monogenea). Aquac., 455: 81-86.

Mikaili, P., S. Mojaverrostami, M. Moloudizargari, and S. Aghajanshakeri, 2013. Pharmacological and therapeutic effects of *Mentha Longifolia* L. and its main constituent, menthol. Anc. Sci. Life, 33(2):131.

Naz, H., N.A. Akram, M. Ashraf, D.I. Hefft, and B.L. Jan, 2022. Leaf extract of neem (*Azadirachta indica*) alleviates adverse effects of drought in quinoa (*Chenopodium quinoa* Willd.) plants through alterations in biochemical attributes and antioxidants. Saudi J. Biol. Sci., 29(3): 1367-1374.

Noroozlo, Y.A., M.K. Souri, and M. Delshad, 2019. Stimulation effects of foliar applied glycine and glutamine amino acids on lettuce growth. Open Agric., 4(1): 164-172.

Osabor V.N., F.I. Bassey, and U.U. Umoh, 2015. Phytochemical screening and quantitative evaluation of nutritional values of *Zingiber officinale* (Ginger). Am. Chem. Sci. J., 8(4): 1-6.

Palá-Paúl, J., J.J. Brophy, R.J. Goldsack, and B. Fontaniella, 2004. Analysis of the volatile components of *Lavandula canariensis* (L.) Mill., a Canary Islands endemic species, growing in Australia. Biochem. Syst. Ecol., 32(1): 55-62.

Rahmani, A., A. Almatroudi, F. Alrumaihi, and A. Khan, 2018. Pharmacological and therapeutic potential of neem (*Azadirachta indica*). Phcog. Rev., 12(24): 250-255.

Rodrigues, M., T.H. Costa, R.A. Festucci-Buselli, L.C. Silva, and W.C. Otoni, 2012. Effects of flask sealing and growth regulators on in vitro propagation of neem (*Azadirachta indica* A. Juss.). In Vitro Cell. Dev. Biol., 48: 67-72.

Sarah, R., B. Tabassum, N. Idrees, and M.K. Hussain, 2019. Bio-active compounds isolated from neem tree and their applications. Natural Bio-active Compounds: Volume 1: Production and Applications, 509-528.

Shabana, M.H., L.K. Balbaa and I.M. Talaat, 2017. Effect of Foliar Applications of *Zingiber officinale* Extracts on *Origanum majorana.* J. Herbs Spices Med. Plants. 23: 89–97.

Shahdadi, F., M. Faryabi, H. Khan, A.S. Sardoei, B. Fazeli-Nasab, B.H. Goh, and C.S. Tan, 2023. *Mentha longifolia* Essential Oil and Pulegone in Edible Coatings of Alginate and Chitosan: Effects on Pathogenic Bacteria in Lactic Cheese. Mol., 28(11): 4554.

Shahdadi, F., M. Shirani, and M. Fryabi, 2021. Investigation of phenolic, chemical compounds and anti-radical properties of *Mentha longifolia* essential oil from the cold region of Jiroft. In Proceedings of the First National Conference on Medicinal Plants, Entrepreneurship and Commercialization, University of Jiroft, Jiroft, Iran, 10–11.

Silva, L.C.D.M.A., F.D.C. de Oliveira Mendes, F. de Castro Teixeira, T.E. de Lima Fernandes, K.R.B. Ribeiro, K.C. da Silva Leal, and R.A.N. Dantas, 2023. Use of *Lavandula angustifolia* essential oil as a complementary therapy in adult health care: A scoping review. Heliyon.

Slattery, R.A., A. VanLoocke, C.J. Bernacchi, X.G. Zhu and D.R. Ort, 2017. Photosynthesis, Light Use Efficiency, and Yield of Reduced-Chlorophyll Soybean Mutants in Field Conditions. Front. Plant Sci. 8: 549.

Slimani, C., H. Sqalli, R.A.I.S. Chaimae, A. Farah, A. Lazraq, L. El Ghadraoui, and G. Echchgadda, 2022. Chemical composition and evaluation of biological effects of essential oil and aqueous extract of *Lavandula angustifolia* L. Notulae Scientia Biologicae, 14(1): 11172-11172.

Snedecor, G.W., and W.G. Cochran, 1994. Statistical methods 8th edition (New Delhi: Affiliated East.

Souri, M.K., M. Hatamian, and T. Tesfamariam, 2019. Plant growth stage influences heavy metal accumulation in leafy vegetables of garden cress and sweet basil. Chem. Biol. Technol. Agric.,6(1): 1-7.

Subapriya, R. and S. Nagini, 2005. Medicinal Properties of Neem Leaves: A Review. Current Medicinal Chemistry Anti-Cancer Agents, 5: 146-149.

Talbaoui, A., N. Jamaly, M. Aneb, A. Idrissi, M. Bouksaim, S. Gmouh, and Y. Bakri, 2012. Chemical composition and antibacterial activity of essential oils from six Moroccan plants. J. Med. Plant Res., 6(31): 4593-4600.

Trease, G.E. and W.C. Evans, 1989. Pharmacognosy. 13th ed. Bailliere Tindall Ltd, London. 389.

Ujah I.I., C.A. Nsude, O.N. Ani, U.B. Alozieuwa, I.O. Okpako and A.E. Okwor, 2021. Phytochemicals of neem plant (*Azadirachta indica*) explains its use in traditional medicine and pest control. GSC biol. pharm. sci., 14(2): 165-171.

Wanas, A.L., and M.I. Khamis, 2021. Effect of Garlic and Licorice Extracts on Vegetative Growth and Leaf Anatomy of Strawberry Plants Cultivated in Different Growing Media. Sci. J. Damietta Fac, Sci. 11(1): 89-102.

Yadegarinia, D., L. Gachkar, M.B. Rezaei, M. Taghizadeh, S.A. Astaneh, and I. Rasooli, 2006. Biochemical activities of Iranian *Mentha piperita* L. and *Myrtus communis* L. essential oils. Phytochem, 67(12): 1249-1255.