Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2019, 11(3): 59-73

Research Article

ISSN: 0975-7384
CODEN(USA): JCPRC5

In Vitro Antioxidant and Antimicrobial Activities of Essential Oils of *Lavandula stoechas* from Morocco

Kaoutar EL Amrani[1*], Mohammed Barbouchi[1], Mostafa EL idrissi[1], Mohammed Sbiti[2], Abderrahim Eddahby[3] and M'barek Choukrad[1]

[1]Laboratory of Molecular Chemistry and Natural Substances, Moulay Ismail University, Faculty of Science, B.P 11201 Zitoune, Meknes, Morocco

[2]Microbiology Laboratory, Military Hospital Moulay Ismail, Meknes, Morocco

[3]Regional Laboratory of Analysis and Research ONSSA Meknes, Morocco

---

ABSTRACT

Many aromatic, medicinal and other plants possess potent phytotherapeutic, antioxidant and antimicrobial properties, leading scientific researchers to use them in many fields such as medicine, pharmacy, cosmetics and agriculture.

Currently, bacterial resistance to antibiotics and the toxicity of synthetic antioxidants have led researchers to take an interest in the plant world given the richness of some plants in natural antioxidants.

It is in this objective that our choice is focused on Lavandula stoechas L., known for its benefits then our work is to valorize this plant by demonstrating and determining its biological properties.

The studied plant is harvested in two different Moulay Idriss zarhoun and ouazzane regions then extracted by hydrodistillation.

The volatile fraction obtained by hydrodistillation was analyzed by coupling GC-MS and its chemical composition was determined. The essential oil consists mainly of 1,8-cineole, Fenchone, d-camphor, bornyl acetate and myrtenyl acetate.

The antioxidant activity of the various essential oils was evaluated by the DPPH radical reduction method (2,2-diphenyl-1-picrylhydrazyl). The results obtained showed the existence of an antioxidant activity of the essential oil of the leaves against it is less important than the flowers.

The antimicrobial power of lavandula essential oils was tested on six bacterial strains: two Gram-positive strains (Streptococcus agalactiae, Staphylococcus aureus), four Gram-negative (Pseudomonas aeruginosa, Escherichia coli, Acinetobacter baumannii, Klebsiella pneumoniae) and a yeast Candida albicans. This test shows that the essential oils have a powerful effect, especially the oil of the leaves of Ouazzane on S. aureus and Acinetobacter boumanni, with a diameter of inhibition up to 24, 22mm. Other oils showed moderate antibacterial activity against Gram (-) and Gram (+) bacteria.

Keywords: Essential oil; *Lavandula stoechas* L; Antimicrobial activity; Antioxidant activity

---

INTRODUCTION

Moroccan flora is a major reservoir of aromatic plants medicinal products whose active ingredients can be used in cosmetics, aromatherapy, pharmacology, perfumery, and food industry [1].

The use of plants for treating diseases is as old as the human. In modern societies, Moroccan society among others, we note a strong trend towards natural products, both for health care, beauty or as food additives as flavors, preservatives or that spices and condiments, even if their chemical constituents are not always completely known. Active compounds produced during secondary vegetal metabolism are usually responsible for the biological properties of some plant species used throughout the globe, including treatment of infectious diseases. Currently, data on the antimicrobial activity of numerous plants have been scientifically confirmed [2]. In Morocco the flora is very rich in medicinal plants which produce valuable natural substances such as essential oil [3]. Actually, essential oil and their components are gaining increasing interest because of their relatively safe status, their wide acceptance by consumers, and their exploitation for potential multipurpose functional use [4]. Many essential oils also have been confirmed to possess the antioxidant activity [5]. Natural antioxidants are also in high demand for application as nutraceuticals as well as food additive because of consumer preferences [6].

The medicinal plants have been used for a long time to treat several diseases [7-10]. *In vitro* pharmacological screening activities have shown that some of these plant species possess several biological activities such as antibacterial, antioxidant [11,12]. As part of the study evaluation of the biological effectiveness of the essential oil from the medicinal plants, the study presented a study of the antioxidant and antibacterial activities associated with the chemical composition of essential oil isolated from *Lavandula steochas* L.

Lavandula is an important medicinal and aromatic plant from the Lamiaceae family which produces essential oils. The plant is used as expectorant, antispasmodic, carminative, a good stimulan, deobstruent, resoluent and wound healing.

Lavandula stoechas L. is an aromatic plant largely used in traditional medicine in Morocco. The essential oil of *L. stoechas* showed several pharmacological activities such as antibacterial [13,14], antioxidant [15], antileishmanial property [16] and anti-inflammatory [17] activities.

MATERIALS AND METHODS

Plant Material

Lavandula stoechas L. (leaves and flowers) were collected from two different regions of Morocco: Moulay Idriss Zerhoun (Region: Fez-Meknes) and Ouazzane (Region: TangierTetouan-AlHoceima), in April. The leaves and flowers of *Lavandula stoechas* L. were air-dried for 15 days at room temperature and then separately hydrodistillated using a Clevenger-type apparatus for 3 hours. The essential oils were dried with anhydrous sodium sulfate and stored in a refrigerator at 4°C until use.

Table 1. Geographical coordinates of the harvesting site

	Moulay Idriss Zarhoune	**Ouazzane**
Latitude (N)	34° 03′ 20″	34° 48′ 00″
Longitude (E)Ouest	5° 31′ 20″	5° 35′ 00″
Altitude	530 m	614 m

Gas Chromatography/Mass Spectrometry

Essential oils of dry leaves and flowers of *Lavandula stoechas* L. were analyzed by GC-MS: Agilent technologies 7890 B, equipped with Agilent 19091S-433 fused silica capillary HP-5MS column (5% phenyl Methylpolysiloxane, 30 m, 250 µm; film thickness 0.25 µm), coupled to mass spectrometer Agilent technologies 5977 A MSD (ion source 230°C, 70ev) GC oven initial temperature was 70 ◦C during 2 min. and programmed to 250 ◦C at a rate of 10 ◦C/min and 250 ◦C during 45 min under the following operation conditions: vector gas: Helium. The injector temperature was 250°C; split ratio of 80/1 was injected; helium was used as the carrier gas at 3 mL/min. Identification of the essential oil components was made by mass spectra with the NIST library (Andriamaharavo, N,R.Retention DATA. NIST mass spectrometry DATA center 2014). As well as by comparing them with those reported in the literature [18,19].

Evaluation of the Antibacterial Activity

Microorganisms

Bacterial strains studied: For the determination of the antimicrobial activity of *L. Stoechas* L. essential oils, six bacterial strains: two Gram positive (Streptococcus agalactiae, Staphylococcus aureus), four Gram negative (Pseudomonas aeruginosa, Escherichia coli, Acinetobacter baumannii, Klebsiella pneumoniae) and a yeast Candida albicans were chosen. These bacteria are pathogenic and are known to their strong antimicrobial resistance and their invasive and toxic power in humans. They are frequently encountered in many infections in Morocco and pose a

problem clinical and therapeutic. All the microorganisms were obtained from the laboratory of bacteriology at the Moulay Ismail Military Hospital of Meknes, Morocco.

Determination of antibacterial activity by the paper disc diffusion method: The diffusion method was used to demonstrate the antimicrobial activity. A bacterial suspension of 18 to 24 hours of each microbial strain is prepared with the nutrient broth, diluted and adjusted to a concentration of 5.105 CFU/ml. Petri dishes (90 mm) containing Mueller Hinton are inoculated by streaking. A disc of 6 mm diameter filter paper (Whatman no. 3) is soaked with 10 µl of essential oil and then placed on a Petri dish and the whole is incubated for 18 to 24 hours at 37°C. After 18 to 24 hours of incubation, zone or a clear halo around the disk is present if the essential oil inhibits microbial growth. More the inhibition zone, the greater the germ is sensitive. All tests were repeated three times [20,21].

Determination of minimum inhibitory concentrations (MIC): This technique involves inoculating, by means of a standardized inoculum, a decreasing concentration range into essential oil. After incubation, observation of the range gives access to the Minimum Inhibitory Concentration (MIC), which corresponds to the lowest concentration of essential oil capable of inhibiting bacterial growth.

128 µL of the essential oil to be tested were dissolved in 5% tween 80 and are placed in a sterile tube containing 3,872 mL of Mueller Hinton. A cascade dilution is carried out in LB medium so as to obtain a concentration range of between 32 µL/mL and 0.125 µL/. 13 µl of a bacterial inoculum, with a density equivalent to the Mac Farland 0.5 standard (107 $CFU.mL^{-1}$), are deposited in each of the tubes of the range, which are then placed at 37°C., after stirring, for 24 hours. A control of bacterial growth, for which 13 µl of the standardized inoculum was deposited in Mueller Hinton, is also carried out.

After incubation, the MIC of the essential oil tested is deduced from the first tube of the range devoid of bacterial growth (tableau 3). Each experiment is repeated twice [22].

Evaluation of Antioxidant Activity

In recent years, interest in natural antioxidants, in relation to their therapeutic properties, has increased considerably. This study was intended for a pre-scanning check of the radical activity of oil isolated from *Lavandula stoechas* L. (Morocco) and to evaluate their effectiveness compared to the synthetic antioxidant ascorbic acid (Vitamin C).

DPPH Radical Scavenging Activities

The effect of each essential oil on DPPH• was measured using the methods described earlier [23]. A volume of 0.1 ml of various concentrations of each essential oils expressed in mg/mL was added to 3.9 ml of ethanolic solution of DPPH• (0.025 g L^{-1}) prepared daily. The mixture was vigorously shaken and left standing at room temperature for 30 min. The absorbance of the resulting solution was then measured at 515 nm after 30 min. The antiradical activity (three replicates per treatment) was expressed as IC50 (mg/mL), the concentration required to cause a 50% DPPH inhibition. The ability to scavenge the DPPH radical was calculated by using the following equation:

$$\text{DPPH scavenging effect (\%)} = ((A_0 - A_1)/A_0) \times 100$$

Where A_0 is the absorbance of the control at 30 min, and A_1 is the absorbance of the sample after 30 min. ascorbic acid was used as a positive control. Tests were carried out in triplicate.

A curve of the percentage of inhibition of the DPPH radical as a function of the concentration of the essential oils is plotted in order to determine the IC50. The lower the IC50 value the greater the antioxidant activity of the extracts [24].

RESULTS AND DISCUSSION

Yield in Essential Oils

The results show that the best yield of essential oil was obtained from samples from the Ouazzane region with an average of (1.15 ± 0.11%, 0.75 ± 0.31%), while those from Moulay idriss zarhoune provided a rate of (0.86 ± 0.06%, 0.57 ± 0.13%). %. These average yields of essential oils have been calculated in relation to the dry plant material (leaves and flowers). The yields obtained with *Lavandula stoechas* L. samples from both provenances (Ouazzane and Moulay Idriss zarhoune) during our study are significantly higher (leaves) than those found by turkie. Algerie for the same species in Tunisie, but roughly equal to those in Greece.

The reasons for this variability can be explained by the differences in environmental conditions (climate and geographical location), the harvest period and the distillation technique (Table 1) [25].

It should also be noted that the production of essential and aromatic oils from the plant results from a series of physiological, biochemical, metabolic and genetic regulations (Table 2) [26].

Table 2. Example of yields of essential oil of *Lavandula stoechas* L. (leaves) in different countries

Origin	Our study	Tunisia	Algeria	Greece	Turkic
R %	1.15	0.77	0.77	1.2	0.8
Réf	-	[27]	[28]	[29]	[30]

Organoleptic Characteristics

The different organoleptic characteristics (appearance, color, smell) of the essence of *Lavandula stoechas* L. have been noted in the following (Table 3).

Table 3. Organoleptic characteristics of *Lavandula stoechas*

	Characteristics	Essential oil			
		Sample studied	Guenther [31]	Menaceur Fouad [32]	Mohammedi Zohra [28]
Organoleptic	Appearance	Liquid	Liquid	Liquid	Limpid
	Color	Light yellow	Light yellow	Light yellow	Yellow
	Smell	camphor	Same smell as	Camphor	Strong

			the luminaries flowering		
Physical	Relative density at 20°C	0.961	0.949	0. 937	0.813

According to the results obtained, we find that the essential oil of *L. stoechas* L. has physicochemical and organoleptic characteristics close to those indicated in the literature.

GC-MS Chromatographic Analysis

Table 4 shows GC–MS chromatograms of essential oils of *L.* stoechas L. flowers and leaves extracted by HD. Generally fenchon and camphor were found as major compounds and associated with 1,8-cineol, and myrtenyl acetate in all essentials oils.

The comparison of the present results with the chemical composition of *L. stoechas* L. Essentials Oils from other countries has shown qualitative and quantitative differences. Skoula et al. [29] had found that fenchone (44.8-45.2%), 1,8 cineole (16.87-16.3%) and camphor (6.2-9.9%) were the major components. In contrast, as shown in Table 4, however the dominant components of lavender species especially *Lavandula stoaches* L. from Turkey, Corsica, Crete, Spain, Cyprus, Morocco and France are camphor and fenchone or cineol and myrtenyl acetate and the levels of linalyl acetate and linalool are very low or absent [31-33]. It is also well known that the fragrance composition of plants varies with the species, cultivation environment, weather condition, region, harvesting season and extraction method.

Table 4. Chemical Composition of the Leaves and Flowers of *Lavandula stoechas* L.

S. No	Compound	Our study				Alberto angioni(2006) Italy		Hasan Kırmızıbekmez (2009)turky	
		Ouazzane		My Idriss Zarhoune					
		Leaves%	Flowers%	Leaves %	Flowers%	Leaves %	Flowers%	Leaves %	Flowers %
1	(R)-α-pinene	0.61	0.52	2.12	-	2.96	0.69	0.7	6.1
2	Camphene	3.81	1.89	2.94	3.63	2.75	2.02	0.6	1
3	β-pinene	0.04	0.03	0.08	0.21	0.07	0.03	0.1	0.2
4	p-Cymene	0.7	0.86	0.63	0.51	0.41	0.38	0.4	0.4
5	Limonene	0.32	0.52	0.42	1.89	1.1	0.91	0.2	3
6	1,8-Cineole(Eucalyptol)	5.54	3.53	6.88	4.88	0.22	0.04	15.6	3.8
7	γ-terpinene	0.09	0.12	0.09	0.13	0.06	0.06	0.1	-
8	Fenchone	13.65	19.34	7.57	9.36	59.48	72.97	41.9	39.2
9	Linalool	0.5	0.26	0.43	0.98	0.41	0.3	0.7	2.1
10	α-campholenal	0.36	0.5	0.56	0.48	0.15	0.15	-	-

11	cis-verbenol	-	0.81	-	0.71	0.04	0.12	-	-
12	Fenchol	0.57	0.89	0.38	0.81	0.51	0.36	-	-
13	d-camphor	16.1	14.56	10.14	9.13	15.36	9.25	-	-
14	p-Mentha-1,5-dien-8-ol	-	-	2	-	0.04	0.02	-	-
15	2-Methoxy-4-vinylphenol	0.08	0.04	1.08	-	-	-	-	-
16	Borneol	1.57	1.32	-	1.29	1.59	0.68	0.2	0.1
17	Thymol	0.86	1	0.59	-	0.01	0.01	-	-
18	p-Cymen-8-ol	0.85	-	-	-	0.31	0.27	-	-
19	α-terpineol	0.29	0.34	-	0.55	-	-	-	-
20	Myrtenal	0.37	0.93	-	-	1.42	0.8	0.2	0.8
21	cis-Verbenone	1.22	1.31	1.22	0.72	-	-	0.5	0.4
22	Fenchyl acetate	0.38	1.25	-	0.86	-	-	0.2	0.5
23	(-)-Carvone	0.34	0.62	0.31	0.38	0.08	0.18	0.3	0.3
24	Bornyl acetate	6.81	7.82	4.66	5.36	2.42	5.1	0.8	1.5
25	Myrtenyl acetate	2.97	5.87	4.25	6.41	5.02	3.69	1.9	9.5
26	Cubebol	1.12	0.78	1.2	1.54	-	-	0.4	0.8
27	epi-Cubebol	0.88	0.66	1.57	1.22	-	-	0.4	1.1
28	δ-Cadinene	1.12	0.75	1.7	1.06	-	-	0.7	0.3
29	Myrtenyl 2-methyl butyrate	-	0.71	-	-	-	-	-	-
30	Eudesma-1,4(15),11-triene	0.78	-	-	-	-	-	-	-
31	Longifolene	0.86	0.92	1.08	-	0.03	-	-	-
32	γ-Selinene	-	3.43	-	-	-	-	-	-
33	γ-Patchoulene	-	2.4	-	-	-	-	-	-
34	allo-aromadendrene	0.13	0.05	0.02	0.15	0.05	0.01	-	0.2
35	γ-Gurjunene	4.95	-	-	2.58	0.01	0.03	-	-
36	γ-Maaliene	3.24	2.4	-	-	-	-	-	-
37	1,10-di-epi-Cubenol	1.05	0.73	1.25	1.01	-	-	-	-
38	2-Isopropyl-5-methyl-9-methylenebicyclo[4.4.0]dec1ene	0.86	1.12	-	-	-	-	-	-
39	α-Cadinol	1.35	-	0.7	0.26	0.04	-	-	-
40	isolongifolene,9,10-dehydro	0.78	-	-	-	-	-	-	-
41	Ylangenal	1.92	1.38	-	-	-	-	-	-
42	Valerenal	1.54	-	2.24	3.95	-	-	-	-
43	Hexyl cinnamic aldehyde	0.76	-	-	-	-	-	-	-
44	Caryophyllene oxide	-	-	-	-	-	-	0.5	0.4
45	Calamenene	-	-	0.76	-	-	-	0.2	0.2

Total		79.37	79.66	56.87	60.06	94.54	98.07	66.6	71.9

Antimicrobial Activity

Antimicrobial activities of *L. stoechas* L. essential oil using disc diffusion method

The *in vitro* results of antimicrobial activity of the EO of *L. stoechas* L. by the paper disk agar diffusion method against microorganisms are summarized in Table 5.

Table 5. Average diameters of the inhibition zones of different strains(mm) grown in the presence of the essential oil *Lavandula stoechas* L

Microorganisms	Inhibition zone diameter (mm)					
	Essential oil of *Lavandula stoechas* (10 µl/disc)				Reference antibiotic	
	Ouazzane		My Idriss Zarhoun		Colistin (25 mg)	Vancomycine (5 mg)
	Leaves	Flowers	leaves	flowers		
Gram negative						
Pseudomonas aeruginosa	6	6	6	6	19	
Escherichia coli	11	6	11	9	12	
Klebsiella pneumoniae	10	6	9	11	18	
Acinétobacter boumanni	22	12	21	20	18	
Gram positive						
Staphylococcus aureus	24	11	13	14		18
Streptococcus agalactiae	16	11	14	12		17
Fungi						
Candida albicans	15	12	17	16	10	

The essential oil of *L. stoechas* L. ouazzane (leaves) was very active against S. aureus with inhibition zone 24 mm and moderately active against E. coli and Streptococcus agalactiae showed an inhibition zone between 16 and 11 mm. flowers oils of ouazzane showeds the least antibacterial activity.

On the other hand oils of the Moulay idriss zarhoun showed moderate antibacterial activity against Acinétobacter boumanni for both parts of the plant (leaves and flowers) and moderately active against other micro-organisms. In addition, all oils are active against candida albicans.

The antimicrobial activity of *L. stoechas* L. was confirmed by the macrodilution assay (Table 6).

Table 6. Antimicrobial activities of *L. stoechas* essential oil using macro-dilution method

Microorganisms	CMI (µl/ml)			
	Ouazzane		My Idriss Zarhoue	
	Leaves	Flowers	Leaves	Flowers
Streptococcus agalactiae	1	-	2	-
Acinétobacter boumanni	1	1	1	-
Staphylococcus aureus	2	-	4	-
Candida albicans	1	2	4	-

L. stoechas L. EO exhibited much higher antibacterial activity with the MIC values of 2 µl/ml against Streptococcus agalactiae and Staphylococcus aureus for leaves of Moulay idriss zarhoun and ouazzane respectively.

The MICs of Staphylococcus aureus and Candida albicans values were 4 µl/ml for leaves of Moulay idriss zarhoun.

Antioxidant Activity

Absorbance measurement (or optical density OD) was performed spectrophotometrically at 517 nm. From the values obtained, we calculated the percentages of inhibition using the formula given previously. The values obtained made it possible to draw the curves of Figure 1, which represents the variation of the percentage of inhibition as a function of the concentrations of the essentials oils. We have graphically determined the concentration corresponding to 50% inhibition (IC50), which constitutes the antioxidant activity of the essentials oils studied.

Value of IC50

The IC50 is conversely related to a compound antioxidant capacity because it expresses the necessary quantity of antioxidant and decreases the concentration of the free radical of 50%. The lower value of IC50 has the most important antioxidant activity. The essential oil of the lavender could bring back the stable free radical 2,2 diphenyl-1-picrylhydrazyl (DPPH•) to the yellow colored diphenylpicryl hydrazine (DPPH). The IC50 calculations are schematized in Figures 1A-1E.

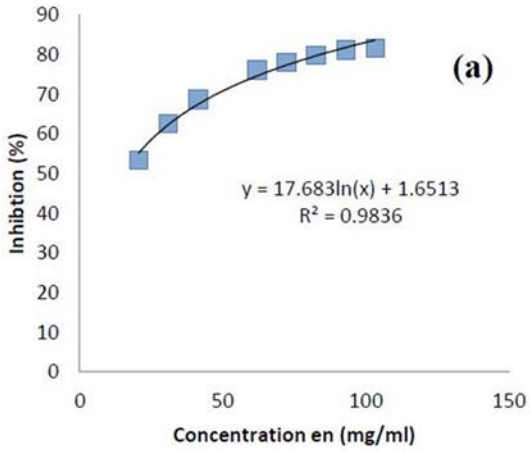

Figure 1A. IC50 calculations for: OE of *L. stoechas* Flowers (MIZ)

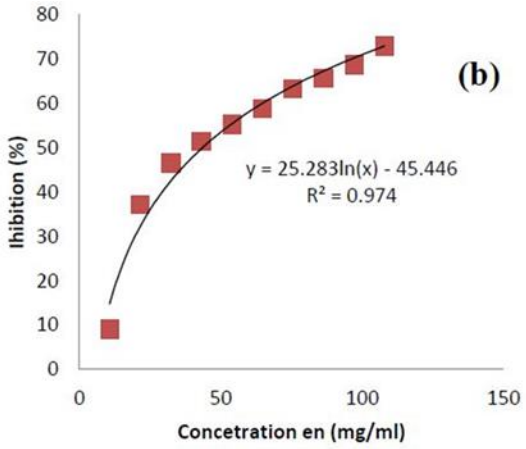

Figure 1B. IC50 calculations for: OE of *L. stoechas* Leaves (MIZ)

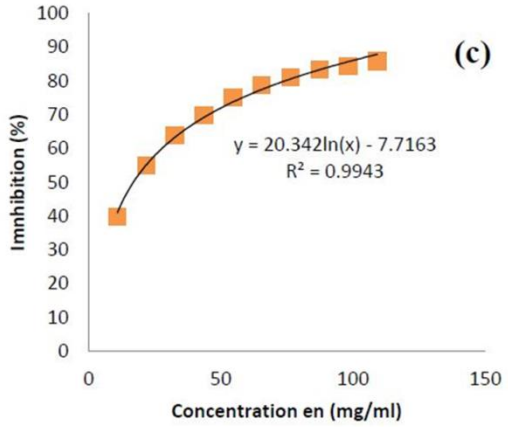

Figure 1C. IC50 calculations for: OE of *L. stoechas* Flowers (W.Z)

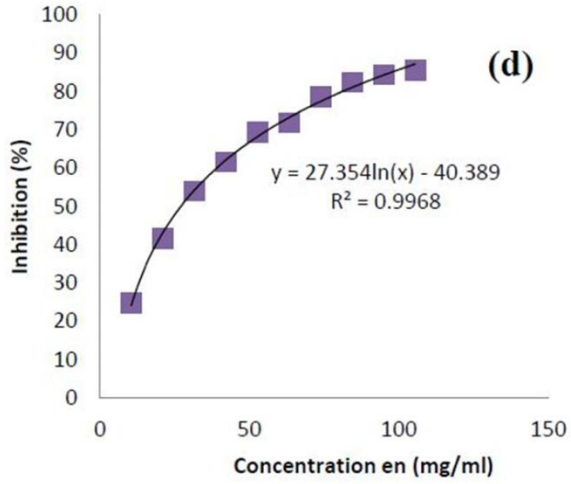

Figure 1D. IC50 calculations for: OE of *L. stoechas* Leaves (W.Z)

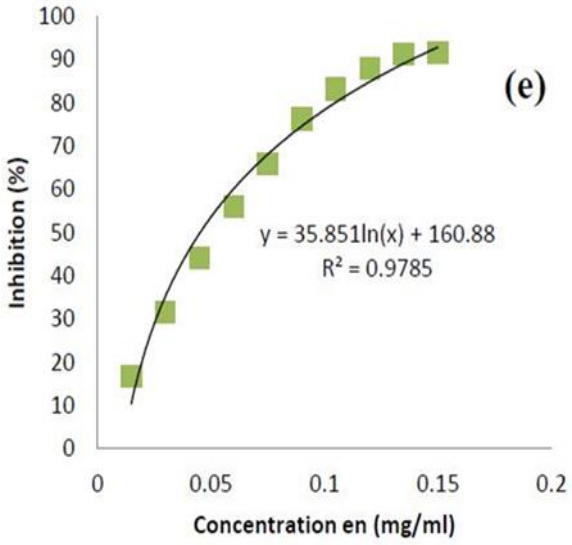

Figure 1E. IC50 calculations for: (e): ascorbic acid

The percentage of inhibition of the free radical increases with the increase in the concentration for either ascorbic acid or for OEs tested.

At a concentration of 0.15 mg/ml, ascorbic acid revealed a percentage inhibition of the DPPH free radical of 91%, while for concentrations of *L. stoechas* L. flowers (MIZ) (103 mg/ml), leaves (MIZ) (108) mg/ml), Flowers (W.Z) (109 mg/ml) and Leaves (105 mg/ml), inhibition percentages obtained are respectively 81 ± 2.64%, 73 ± 2.50%, 85 ± 0.61 and 85 ± 0.07%.

The IC50 values determined graphically in mg/ml expressing the effective concentration of the different OEs is shown in Table 7.

Table 7. Result of the antioxidant test expressing the effective concentration 50% in mg/ml

O.E de L.S/standard	EC50 ± standard deviations
Flowers (MIZ)	15.39 ± 2.64
Leaves (MIZ)	43.6 ± 2.50
Flowers (WZ)	17.06 ± 0.61
Leaves (WZ)	27.23 ± 0.07
Ascorbic acid	0.045 ± 0.003

The study of the antioxidant activity of HEs according to the method of DPPH free radical scavenging showed that all the oils studied have moderate antioxidant activity and that the essential oils of the two region flowers have higher activity than the leaves. It also seems that this activity is related to the presence of the phenolic compounds in essential oil. The main role of these components as reducer of the free radicals has been previously reported [34]. The camphor which is the major compound of our essential oil with a concentration of 11.25% has a strong antioxidant activity [35]. In fact, only the chief compounds of essential oil are responsible for this antioxidant activity. However, there can be also other less important compounds that can interact in a synergistic or antagonistic way to create an effective system with respect to the free radicals [36,37]. The presence of carvacrol even with weak concentration in the essential oil of *L. stoechas* L. (0.9%) can explain the activity of trapping of radical DPPH.

CONCLUSION

Our work was devoted to the study of the chemical and biological profiles of the essential oil extracted from *Lavandula stoechas* L., by comparing two batches of different provenances: Moulay Idriss Zarhoun and Ouazzane from Morocco. The effect of provenance on yield in essential oil was very marked. The best oil content essential was obtained with samples from Oazzane (1.15%, 0.75%), compared to that of Moulay Idriss Zarhoun (0.86%, 0.57%) leaves and flowers respectively.

Qualitative and quantitative analysis of the two batches of essential oils identified fenchone (13.65-19.34/7.57-9.36%), camphor (16.1-14.56/10.14-9.13%), bornyl acetate (6.81-7.82/4.66-5.36%) and myrtenyl acetate (2.97-5.87/4.25-6.41%) as the main constituents. respectively for Ouazzane and Moulay Idriss Zarhoun.

The difference in yield and chemical composition of the two batches analyzed can be attributed to several factors such as the characteristics of climatic and edaphic conditions typical of each region.

The evaluation of antioxidant properties is an interesting task and useful, especially to find new sources of agents antioxidant and natural antimicrobials. In this context, we have tried to evaluate the antioxidant activity of oil extracted from *Lavandula stoechas* L.

Staining of ethanolic DPPH solution with Lavandula confirms that it has exceptional antioxidant activity. So, this oil can be considered as an antioxidant the natural ability to prevent the oxidation and alteration of certain food.

All the microorganisms studied showed growth inhibition in contact with the two lots of essential oils. However, the results of the antimicrobial activity of the two provenances are different according to the strains tested. The essential oil from Ouazzane has a more pronounced antimicrobial activity compared to that of Moulay Idriss Zarhoun, probably due to their difference in chemical composition.

This study can be considered as a primary source of information on *Lavandula* species of Moroccan flora, widely used in traditional medicine. It is part of a perspective of diversification of cash crops and more generally, valorization of aromatic and medicinal plants of the Morocco.

REFERENCES

[1] J Bellakhdar. The Traditional Moroccan Pharmacopoeia. Ancient Arab Medicine and Popular Knowledge, Ibis Press, Paris. **1997,** 759.

[2] NCC Silva; A Fernandes; *J Venom Anim Toxins Incl Trop Dis*. **2010**, 16, 402-413.

[3] M Hmamouchi. Les Plantes Médicinales et Aromatiques Marocaines. (2nd edn). **2001**.

[4] M Boukhris; G Regane; T Yangui; S Sayadi; M Bouaziz; *J Arid Land Stud*. **2012**, 22(1), 329-332.

[5] H Zhang, F Chen, X Wang, HY Yao. *Food Res Int*. **2006**. 39, 833-839.

[6] A Neffati; I Bouhlel; M Ben Sghaier; J Boubaker; I Limem; S Kilani; I Skandrani; W Bhouri; J Le-Dauphin; D Barillier; R Mosrati; L Chekir-Ghedira; K Ghedira. *Environ Toxicol. Pharmacol*. **2009**, 27, 187-194.

[7] A Ennabili; N Gharnit; El Hamdouni; EL Stud. *Bot*. **2000**, 19, 57-74

[8] A Merzouki; F Ed-derfoufi; M Mesa. *J Fitoterapia*. **2000**, 71, 278-307.

[9] A Merzouki; F Ed-derfoufi; M Mesa. *J Ars Pharmaceutica*. **2003**, 44, 59-67.

[10] A Bouyahya; J Abrini; A Et-Touys; Y Bakri; N Dakka. *Europ J Integ Med*. **2017**, 13, 9-25.

[11] A Et-Touys; H Fellah; M Mniouil; A Bouyahya; N Dakka; EH Abdennebi; A Sadak; Y Bakri. *Brit Micro Res J*. **2016**, 16, 1-10.

[12] EO Khay; A Bouyahya; K El-Issaoui; S Zinebi; J Abrini. *Int J Curr Res Biosci Plant Biol*. **2016**, 3, 29-35.

[13] I Dadalioglu; GA Evrendilek. *J Agric Food Chem*. **2004**, 52, 8255-8260.

[14] ME Idrissi; KE Amrani; C M'barek; L Louzi. *World J Pharm Pharm Sci*. **2016**, 9, 2278-4357.

[15] A Carrasco; A Ortiz-Ruiza; R Martinez-Gutierrezb; V Tomasc. *J Indus Crop Prod*. **2015**, 73, 16-27.

[16] A Bouyahya; Y Bakri; EO Khay; F Edaoudi; A Talbaoui; A Et-Touys; J Abrini; N Dakka. *Asian Pac J Trop Dis*. **2017**, 7, 57-64.

[17] EZ Yassine; B Dalila; EM Latifa; B Smahan; S Lebtar; A Sanae; F Abdellah. *J Pharmacogn Phytochem*. **2016**, 8(1), 31-37.

[18] RP Adams. Identification of essential oil components by gas chromatography/mass spectroscopy. Illinois: Allured Publication Corp. **1995,** pp. 69-3510.

[19] RP Adams. Identification of Essential Oil Components by Gas Chromatography/mass Spectrometry. Quadrupole. Allured Publication Corp., Carol Stream, Illinois. **2001**.

[20] IHN Bassole. Pharm Méd Trad. **2001**, 11, 37-51.

[21] M kumar; RC Agarwal; S Dey; VK Rai; B Johnson. *Int J Curr Pharm Res*. **2009**, 1(1).

[22] E Guinoiseau. Biochimie - Biologie moléculaire. Faculté des Sciences et Techniques. Universite de Corse. France. **2010**, pp: 148.

[23] C Sanchez-Moreno. *J Food Sci Technol Int*. **2002**, 3, 121-137.

[24] C Popovici; I saykova; Tylkowski B. *e-Re. Ind*. **2009**, 4, 25-39.

[25] M Lahlou. *Phytother Res.* **2004**, 18, 435-448.

[26] M Costa, JMF Nogueira, MG Miguel, A Romano. *J Hortic Sci Biotech,* **2003**, 78(3): 310-314.

[27] N Bouzouita; F Kachouri; M Hamdi; MM Chaabouni; RB Aissa; S Zgoulli; P Thonart; A Carlier; M Marlier; GC Lognay. *J Essent Oil Res*. **2005**, 17, 584-586.

[28] M Zohra; ATIK Fawzia. *Nature Technol*. **2012**, 34, 39.

[29] M Skoula; Chedlyabidi; Eugenekokkalou. *Biochem Syst Ecol*. **1996**, 24 (3), 255-260,

[30] H Kırmızıbekmeza; B Demircib; E Yeşiladaa; KHC Başerb; F Demircib. *Nat Prod Commun.* **2009**, 7, 1001-1006.

[31] E Guenther. The essential oils. Edition: Robert Krieger publishing co Huntington, New York, **1974** (3), 777.

[32] M Fouad. Composition chimique et activité biologique des huiles essentielles et extraits du romarin (Rosmarinus eriocalyx) et de lavande (*Lavandula stoechas*). Université de Bouira. **2011**, pp:115.

[33] ES Giray; SD Kırıcı; A Kaya; M Turk. *Memet Inan Talanta*. 2008, 74, 930-935.

[34] D Villano; MS Fernandez-Pachon; ML Moya; AM Troncoso; MC GarciaParrilla. *Talanta*. **2001**, 71,230-235.

[35] KP Svoboda; JB Hampson. Plant Biology Department, SAC Auchincruive, Ayr, Scotland UK, KA6 5HW, **1999**.

[36] F Lu, LY Foo. *Food Chem*. **2001**, 75, 197-202.

[37] R Sing; P Marimuthu; CS De-Heluani; ANC Ceser; *J Agric Food Chem*. **2006**, 54, 174-181.