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Antibacterial, antifungal and antioxidant activity of lavandula angustifolia of the middle atlas central (Morocco)

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Abstract

The present work was undertaken with a view to enhancing the aromatic and medicinal plants of the region of Dayet Aoua (Middle Atlas, Morocco), more particularly of one of the most answered plants in the region and which has great value. added for the Moroccan pharmacopoeia in general; it is none other than lavender (Lavandula angustifolia). The chromatographic analysis highlights the major components of the essential oil of lavender. Monoterpenols are represented by a dominance of linalool (33.74% to 38.74%), followed by monoterpenols. The microbiological tests of the essential oils of Lavandula angustifolia revealed that they have an important antibacterial power against gram-positive bacteria in comparison with Gram-negative bacteria. It should also be noted that the essential oil of lavender has an inhibitory effect on mycelial growth against A. alternata, B. cinerea and F. oxysporum; the B. cinerea strain seems to be the most sensitive to these HEs compared to the other strains represented by F. oxysporum and A. alternate. Finally, it should also be noted that according to the results obtained, the fixed oils of Lavandula show an anti-radical activity by the inhibition of the DPPH, this activity increases according to the concentration. Given all the important data that show the characteristics and importance of this plant, which has been confirmed and supported through this study, it seems necessary to intervene all intervention and jealous of officials and researchers as well as citizens in order to maintain this plant in order to sustain this kind of plants on the one hand and from, On the other hand, the conservation of biodiversity in Morocco in general and in this region in particular.

Keywords: *Lavandula angustifolia; Hydrodistillation ; GC MS; biological activity*

1. Introduction

At the crossroads of Europe and Africa, Morocco enjoys a privileged geographical location bordered by the Mediterranean Sea and opens up to the vastness of the Atlantic Ocean. Central then dry south this location makes. Adding to this geography is the choice that allows them to enjoy various aspects of the ecosystem, in addition to the ancient geographical geographical history derived from the mixture and blending of Ethiopian and European animals.

Thanks to all these dimensions, Morocco is a singular region, for more than one reason, and more particularly in terms of biodiversity. It sits at the top of the world rankings in terms of diversity in aromatic and medicinal plants (MAPs). Culinary arts, aromatherapy, cosmetics, herbal medicine and others, have made MAPs paradise plants with multiple uses [1-2]. More than 4200 species have been identified; 400 of them are designated as a medicinal and aromatic product [3] with an endemism rate of over nineteen percent. However, only a few dozen of these species are actually exploited. While it is true that many efforts are being made to promote MAPs, the fact remains that this sector is still not put in its proper place and deserves more attention because of the major shortcomings, in link with its ethnobotanic and the pharmacological virtues of these plants. Faced with a promising and increasingly demanding national and international market, a growing concern for clean green chemistry and an awareness of the concept of sustainable development, the scientific authorities are finding it necessary to orient themselves more and more. More towards innovative research components working to enhance this Moroccan floristic heritage. It is in this sense that the present investigation, whose purpose is to highlight the essential oils of an aromatic and medicinal plant, emblematic of the Moroccan pharmacopoeia: Lavandula angustifolia (lavender), focuses on the possible antioxidant powers; antibacterial and antifungal of its essential oils extracted by the technique of hydrodistillation by Clevenger assisted by microwave. One of the main reasons behind the selection of this type of plant as a place to research and deepen its composition also, its importance is the presence of this type of plant on a very large area in Morocco on the one hand, on the other hand.

2. Materials and methods

2.1. Study area Dayat Aoua (Central Middle Atlas)

Morocco is characterized by several areas that are considered the most beautiful, which are important tourist sites of nature and scenic temptation to visit and summer, most of which is centered in the Mediterranean Atlas known for its majestic mountains and waterfalls, including Daya »Awa», located entirely in the mountains from 1450 m to 1800 m It covers an area of 50,000 hectares.

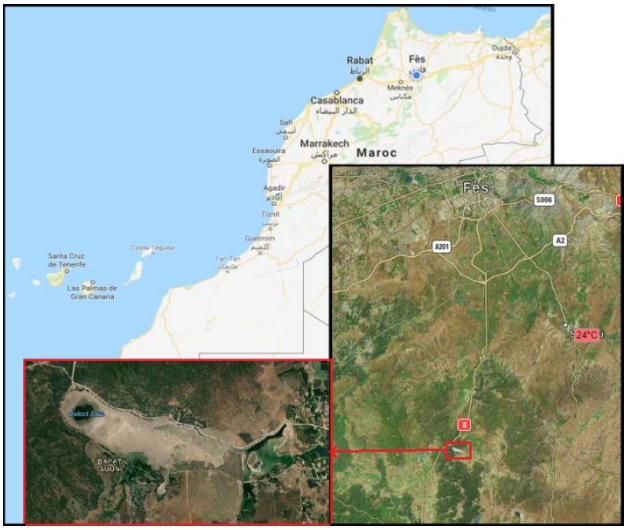

Figure 1. Presentation of the site of Dayat Aoua (Central Middle Atlas)

This region is known for the beauty of its nature and the freshness of its climate, it is thus a tourist area par excellence. This region is mostly occupied by a holm oak forest, swamps and the lake itself. The lithology of Dayet Aoua is mainly karstic. This Causse is dominated by calcareo-dolomitic formations of the lower and middle Lias with the presence of numerous faults favoring the circulation of large quantities of water within the aquifers. A hydrological richness that endows the region with an important plant cover including aromatic and medicinal plants.

2.2. Studied plant Lavandula angustifolia

Lavender is one of the most important aromatic plants in the world. It is one of the main aromatic and medicinal plants exploited and cultivated in several countries around the Mediterranean. It is a small dicotyledonous shrub of the family Lamiaceae, tufted, with erect branches, up to 60 cm in height. Very vigorous and adapting well to the calcareous and rocky soils, the lavenders, originating from the South of Europe, were introduced successfully in the Maghreb [4] .Used as expectorant, antispasmodic, carminative, wound disinfection, against skin problems, psoriasis, has antimicrobial, anti-carcinogenic and anti-inflammatory properties and insecticides [5].

2.3. Extraction of essential oils

2.3.1. Essential oils

Among the major originalities of plants is their ability to produce very diverse natural substances. In fact, alongside conventional primary metabolites, carbohydrates, proteins, lipids, they frequently accumulate secondary metabolites. These fragrant products, generally of complex composition, obtained from a botanically defined plant raw material, either by entrainment by steam or other process are called essential oils (EOs). It is a mixture of various molecules, including in particular terpenes, and oxygenated compounds (alcohols, aldehydes, ketones). The latter represent an important source of molecules that can be used by humans in fields as different as pharmacology or agri-food [6]. EOs are usually classified according to the chemical nature of the major active ingredients, more rarely the extraction method, or the biological effects. We retain 8 main classes: Sesquiterpene carbides; terpene carbides, alcohols, esters and alcohols, aldehydes, ketones, phenols, ethers and peroxides). These are the active ingredients that give the plant its antibacterial therapeutic potential; antifungal and antioxidant [7].

2.3.2. Extraction technique

During this research work, we opted for microwave assisted distillation by Clvenger. The essential advantage of this process is to considerably reduce the distillation time (reduced to a few minutes) and increase the extract yield. Based on a relatively simple principle, microwave assisted solventless extraction involves placing the plant material in a microwave reactor without the addition of water or organic solvent. The plant material is therefore placed in the presence of a sufficient amount of water in a flask disposed in the enclosure of the microwave oven. We set the temperature (energy = 600Watt) and for each sample we did three cycles of 35 min. In this method, the milled plant is heated by microwave radiation in a chamber, whose pressure is reduced sequentially. The heating of the water contained in the plant, creates inside the oil glands a pressure that breaks the plant walls and releases the content in essential oils. A cooling system outside the microwave oven allows the condensation of the distillate, composed of water and essential oil, subsequently easily separable by simple decantation.

2.4. Characterization of essential oils

2.4.1. Physicochemical characterization

We have determined the physicochemical characteristics and the yield of these essential oils extracted according to the protocol described in the European pharmacopoeia [8]. These physicochemical characteristics are:

- Density: using a densimeter type.METTLER TOLEDO 30 PX
- Rotating Power: using an polarimeter ATAGO AP300.
- Refractive Index: using a refractometer type NAR-1TLIQUID

2.4.2. Dosage of secondary metabolites

✓ Determination of polyphenols

The principle of the assay is based on the method using the Folin-Ciocalteu reagent. The protocol used is that of (Marigo, 1973) [9].

✓ Determination of condensed tannins

The protocol is based on the property of tannins that turn into anthocyanins by heating in an acid medium [10].

✓ Determination of flavonoids

The flavonoid assay is performed according to the aluminum trichloride (AlCl3) method (Bahorum, 1996) [11].

2.4.3. Chromatographic analysis

According to the standards and bases adopted by the international standards (ISO) there. We opted for gas chromatography coupled with mass spectrometry [12]; which combines the performance of gas chromatography, for the separation of compounds from a sample, and mass spectrometry, for the detection and identification of compounds based on their mass-to-charge ratio. This technique makes it possible to precisely identify and / or quantify numerous substances present in very small quantities, even in traces. The analysis was conducted using the "Technologies 6890 System N Network GC" hardware. The injector and detector temperatures were set at 250 and 280 ° C. The carrier gas (helium) flow rate was 1.0 ml / min.

2.5. Evaluation of antioxidant activity

An antioxidant is an agent that prevents or slows down oxidation by neutralizing free radicals. Excess free radicals are responsible for cellular damage, especially on DNA, and can promote diseases such as cancer. The antioxidant activity of a compound is its ability to resist oxidation. The most known antioxidants are β-carotene (provitamin A), ascorbic acid (vitamin C), tocopherol (vitamin E) and phenolic compounds. These are able to retard oxidation by indirect mechanisms such as oxygen reduction [13]. The antioxidant activity of the extracted essential oils is carried out by the β-carotene / linoleic acid test. This method evaluates the ability of the oil to reduce the oxidative loss of β-carotene in a β-carotene-linoleic acid emulsion [14].

2.6. Evaluation of antibacterial activity

Antibacterial activity is evaluated by the agar diffusion technique [15]. The bacterial strains chosen for this study are pathogenic bacteria that are frequently involved in the contamination and alteration of foodstuffs (Table 1). The minimum inhibitory concentration (MIC) of essential oils is determined by the micro-dilution technique using resazurin [16].

Table 1. Botanical names and references of bacterial strains used.

bacteria	Strains	References
Gram positive	Staphylococcus aureus	CIP 483
	Bacillus subtilis	CIP 5262
Gram negative	Escherichia coli	CIP 53126
	Pseudomonas aeruginosa	CIP 82118
	Salmonella entérique	CIP 8039

2.7. Assessment of antifungal activity

The antifungal activity is carried out for the essential oils extracted by the HDC method and HDC Microonde. The experiment is carried out in-vitro using the disk diffusion method against Alternaria alternata, Botrytis cinerea and Fusarium oxysporum. The test fungi are developed on PDA medium (Appendix 2) and the inhibitory effect of the essential oils against these fungi is tested on Czapek-Dox agar medium.

3. Results and Discussions

3.1. Physico-chemical characterization of essential oils of lavender

3.1.1. Physical properties

It was used to determine the physical properties of EOs bodies extracted by distillation by Clevenger and the results are shown in Table 2. Analysis of the data collected reveals that the three parameters studied align with the AFNOR standards. This reflects the degree of efficiency of the hydro distillation method recommended for this study.

Table 2. Physicochemical parameters of essential oils compared to AFNOR standards

Physical properties	Distillation By Clevenger assisted by microwave	Standard AFNOR
Refractive index at 20°C	1.465	$1.463 \leq n \leq 1.468$
Relative density at 20 ° C	0 ,893	$0,891 \leq d \leq 0,899$
Rotatory power at 20 ° C	-4	$-7,0° \leq \alpha \leq -3,0°$.

3.1.2. Chemical characterization

The chemical composition of the essential oils of Lavandula angustifolia obtained by HDC microwave is used in Table 3. The analysis in Table 3 highlights the major components of the essential oil of lavender. Monoterpenols are represented by a dominance of linalool (38.74%). The terpene esters are present with a percentage close to that of monoterpenols, noting the abundance of linalyl acetate followed by camphor. Finally, we can say that the oils studied are rich in monoterpenols and the terpene esters on the other hand are less rich in terpene oxide and sesquiterpenes. the small percentage is marked by monoterpenes. By comparing these results with those obtained in a similar study [17], we find that the chemical composition of essential oils is the same with some more or less significant differences.

3.2. Antibacterial activity

The method of diffusion of the wells allowed us to highlight the antibacterial power of essential oils of Lavandula angustifolia vis-à-vis five bacteria. The zones of inhibition are shown in Table 4. According to the classification of Ponce and al. (2003) [18], the zones of inhibition, varying between 7 and 29mm, indicate that all the strains are sensitive to the essential oil of Lavandula angustifolia.

Table 3. Majority compounds of the essential oils studied extracted by HDC-microwave (-) low percentage

Compounds	HDC Microwave (%)
Monoterpènes	
alpha-pinène	-
myrcène	-
limonène	-
ocimène	-
bétapinène...	-
Monoterpénols	
linalol	38.74
terpinène-4-ol	4.70
bornéol	2.36
Sesquiterpènes	
béta-caryophyllène	1.60
(E)-béta-farnésène	0.34
germacrène-D	0.70
gamma-cadinène	0.24
Esters terpéniques	
acétate de linalyle	25.28
acétate de lavandulyle	1.38
Cétone : camphre	10.85
Oxyde terpénique	
1,8-cinéole	3.84
Totale	90,03

Table 4. Diameters (mm) of the zones of inhibition of Lavandula EO.

Strains	DCM	Linalol	Chloramphenicol
Staphylococcus aureus CIP 483	17	25	37
Bacillus subtilus CIP 5262	25	29	35
Escherichia Coli CIP 53126	19	20	35
P. aeruginosa CIP 82118	14	15	34
Salmonella enterica CIP 8039	21	23	37

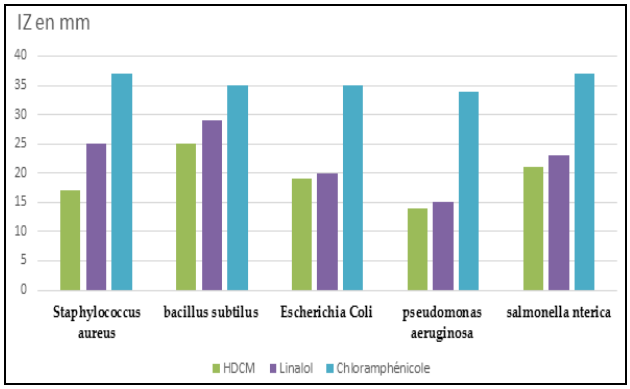

Figure 2 . Antibacterial activity of lavender essential oil extracted by HDCM against pathogenic bacteria (zone of inhibition (IZ) measured in mm).

The results of the disc diffusion test indicate that the essential oil tested exhibits significant antibacterial activity against gram-positive bacteria (IZ 9-29) compared to gram-negative bacteria (IZ 7-20). It can also be seen that linalool, a main component of Lavandula angustifolia, shows better antibacterial activity than Lavandula essential oil.
The results obtained reveal an almost similar antibacterial effect of lavender EO in comparison with other studies, and the essential oil of lavender extracted shows a significant activity. Several studies [19-20-21-22] have reported that Gram (+) bacteria are more susceptible to essential oils than Gram (-) attributed to the presence of an outer membrane impervious to hydrophobic compounds through its lipopolysaccharide coating.The absence of this barrier in Gram (+) bacteria allows direct contact of the hydrophobic components of the essential oil with the phospholipidic bilayer of the cell membrane, thus causing either an increase in the permeability of the ions and the escape of vital intracellular constituents, ie a deficiency in the enzymatic system [20-22- 23- 21] . The results obtained are in agreement with those of Chahboun and al. (2015) [24] and Jianu and al. (2013) [25] who observed a significant sensitivity in Staphylococcus aureus to the essential oil of lavender.Table 5 shows the results of the minimum inhibitory concentration (MIC) of lavender essential oil against pathogenic bacteria.

Table 5. MIC of Lavender essential oil extracted against pathogenic bacteria.

Strains	HDCM (mg/ml)	Linalol (mg/ml)	Chloramphenicol (mg/ml)
B. subtilus CIP 5262	0,511	0,557	0.095
Escherichia Coli CIP 53126	0,535	0,675	0,050
Staphylococcus aureus CIP 483	0,355	0,412	0,095
S. enterica CIP 8039	0,89	0,97	0,050
P. aeruginosa CIP 82118	1,228	1,443	0,05

In this study, we used the modified resazurin microplate assay to evaluate the antimicrobial activity of essential oils. This method provided reproducible and accurate results and allowed a direct comparison of the antibacterial activity of the essential oils tested. The mean minimum inhibitory concentration of Lavandula angustifolia EO varies between 0.332(mg/ml) against Staphylococcus aureus and 1.273 (mg /ml) against Pseudomonas aeruginosa. This result is in agreement with the result obtained by Cantore and al. (2004) [26]who reported that Gram-positive bacteria such as Staphylococcus aureus are more sensitive to vegetable essential oils than Gram-negative bacteria in particular E. coli., was confirmed by the study of Tepe and al., (2006) [27] showed that the antibacterial activity of essential oils. Chloramphenicol showed stronger antibacterial activity with significant inhibition zones of 36 mm and MICs of 0.05(mg/ml).

3. 3. Antifungal activity

An exhaustive analysis of Tables 6 and 7 highlights the antifungal potential of the essential oils of lavender against A. alternata, B. cinerea and F. oxysporum. Three different concentrations tested on boxes of PDA medium (agar, potato and dextrose) showed antifungal properties. Lavandula angustifolia oil completely inhibited mycelial growth of B. cinerea throughout the incubation period. The oil level of 5 and 10 ppm was ineffective against mycelial growth of A. alternata, while the concentration of 40 ppm showed partial antifungal activity.

Table 6. Antifungal effect of lavender HEs on mycelial growth of the fungi studied (mm).

Incubation (days)	EO concentration (ppm)	*Fus. oxysporum*	*B. cinerea*	*A. alternata*
1	5	-	-	-
	10	-	-	-
	40	-	-	
	Witness	-	-	-
2	5	8	-	13
	10	13	-	21
	40	12	-	8
	Witness	14	11	14
3	5	10	-	24
	10	23	-	39
	40	21	-	13
	Witness	28	11	25
4	5	17	-	26
	10	27	-	41
	40	25	-	15
	Witness	28	11	29
5	5	21	-	32
	10	29	-	35
	40	25	-	19
	Witness	35	12	36
6	5	34	-	34
	10	40	-	46
	40	38	-	19
	Witness	38	16	48
7	5	34	-	55
	10	40	-	59
	40	41	-	39
	Witness	34	17	52
8	5	46	-	59
	10	52	-	40
	40	48	-	60
	Witness	50	18	60
9	5	50	-	73
	10	55	-	69
	40	50	-	54
	Witness	56	19	66
10	5	55	-	67
	10	62	-	69
	40	62	-	57
	Witness	60	20	70

The three concentrations showed an inhibitory effect against F. oxysporum according to the control up to 8 days of incubation, while 5 ppm of oil showed a lower inhibitory effect beyond 10 days of incubation.

It is noted that B. cinerea is the most sensitive strain to EO lavender. If the concentration of the EO is increased to 10 ppm, it is observed that the percentage of inhibition reaches 100%, which shows the antifungal power of this EO at this concentration regardless of the extraction method. Regarding the strains F. oxysporum and A. alternata; the data collected shows that the percentage of inhibition decreases as a function of the treatment time and also decreases as a function of the EO concentration of the lavender. From this analysis it can be deduced that the EO of lavender has a greater or lesser antifungal power with respect to treated molds. In addition, the B. cinerea strain seems to be the most sensitive to these EOs compared to the other strains represented by F. oxysporum and A alternata. The effect of treating Botrytis cinerea with lavender EO as compared to an untreated control showed that lavender HE had an inhibitory effect on mycelial growth of Botrytis cinerea at a dose of 10 ppm compared with control (A) which shows the maximum growth. These results are in agreement with those of Laib (2011) [28] who showed an effectiveness of essential oils in the fight against mold. The different isolated genera do not have a similar sensitivity to EO. Most seemed sensitive, Chu and Kemper (2001) [29] have also shown that the antifungal power is related to the volatile components of lavender oil and that are: α pinene, β pinene, P cimene and 1,8 Cineole. These components are present in the essential oil of Lavandula officinalis with the predominance of 1.8 cineole at a concentration of 13.25%. Linalol, which is a major component of the essential oil of Lavandula officinalis, is known for its antifungal activity [30]. As a result, the antifungal effect on molds of dried vegetables is mainly due to Majority components of the oil.

Table7. Antifungal effect of lavender HEs on mycelial growth fungi (% inhibition during three periods of incubation)

Incubation (days)	EO concentration (ppm)	*Fus. oxysporum*	*B. cinerea*	*A. alternate*
1	5	100	100	100
	10	100	100	100
	40	100	100	100
	Witness	100	100	100
5	5	40	100	11,11
	10	17,14	100	2,77
	40	28,57	100	47,22
	Witness	0	0	0
10	5	8,33	100	4,28
	10	-3,33	100	1,43
	40	-3,33	100	18,57
	Witness	0	0	0

3.4. Antioxidant activity

The antioxidant activity of the essential oil of Lavandula angustifolia and its main components were determined by the β-carotene bleaching test. The result of the inhibitory activity of the lipid peroxidation of essential oils evaluated by the β-carotene bleaching test is represented in FIG 3. The essential oil of lavandula angustifolia has shown a high antioxidant capacity. With a maximum of 83% approaching the percentage recorded by the BHT (84%). Linalool, a major component of the essential oil, has also demonstrated a strong antioxidant activity of 82% very similar to that of BHT. It can therefore be suggested that the antioxidant effect of lavender EO is due to its major compound linalool. The concentration inhibiting 50% (IC 50) beta-carotene was calculated is shown in Table 8. The data collected in Table 8 show that the IC50 of linalool (11.45 ± 0.03) and the BHT (16.10 ± 0.04) are lower than the essential oil of Lavandula angustifolia. It is very difficult to attribute the antioxidant effect of a total essential oil to one or a few active ingredients, because an essential oil always contains a mixture of different chemical compounds. t is not only

the major constituents of EO that are responsible for this antioxidant activity, but there may also be other minority compounds that can interact in a synergistic or antagonistic way to create an effective system vis-à-vis free radicals [31- 32] .

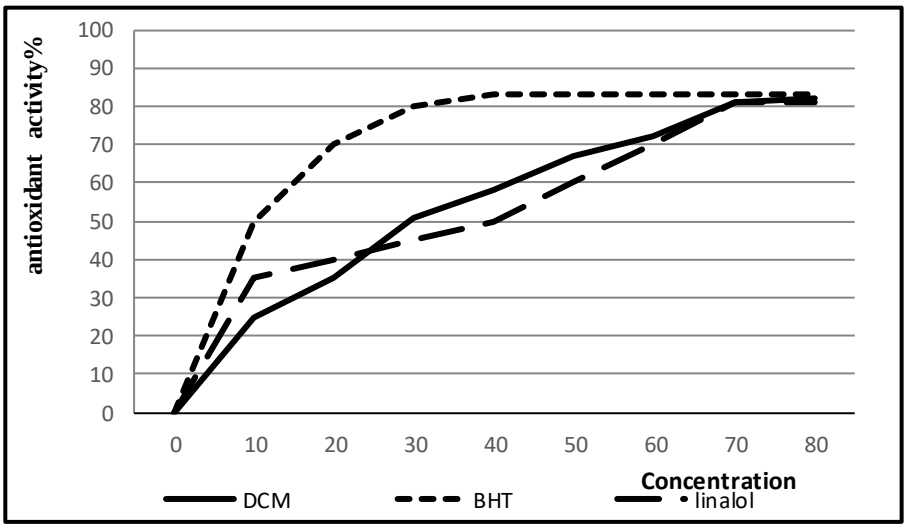

Figure 3. Percentage of antioxidant activity of *Lavandula angustifolia* EO and assay of linalool by β-carotene compared to hydroxytoluene.

Table 8. IC50 values of lavender and linalool HE and BHT by β-carotene bleaching test.

	BHT	Linalol
IC50 value (mg/ml)	16,10 ±0.04	11,45 ±0.03

3.4.1. Test of antioxidant activity

In this test, an attempt was made to evaluate the antioxidant power of the crude methanolic extract and the various flavonoid fractions prepared, as well as the fixed oils. This through the spectrophotometric method at DPPH. It has a dark purple color that will turn pale yellow, which decreases its absorbance to 517nm, when it is reduced by antioxidant compounds giving it a proton or an electron.

3.4.2. Raw methanol extract

After 30 minutes of incubation of the DPPH-extract solution (at different concentration), the purple color turns to a yellow color, this color change is due to the reduction of DPPH, which shows that the samples have a scavenger effect of radical DPPH. The results of the antiradical power of ascorbic acid and crude methanolic extracts of Lavandula are shown in figure 4. From the data obtained, the results of the antibacterial activity test show statistically significant variations. It should also be noted that Lavandula angustifolia shows a clear variation in antioxidant activity in methanolic extracts as a function of concentration, and the curve above shows that the higher the concentration of these extracts. It was observed that the DPPH inhibition rate reaches 80%. The fraction of ethyl acetate shows a lower antioxidant activity than the chloroform fraction and the fraction n-butanol, they reached 7%, 35%, 70% inhibition

respectively at concentrations close to 15000 mg / ml. The n-butanol fraction showed the most important activity of the different fractions of Lavandula flavonoids studied.

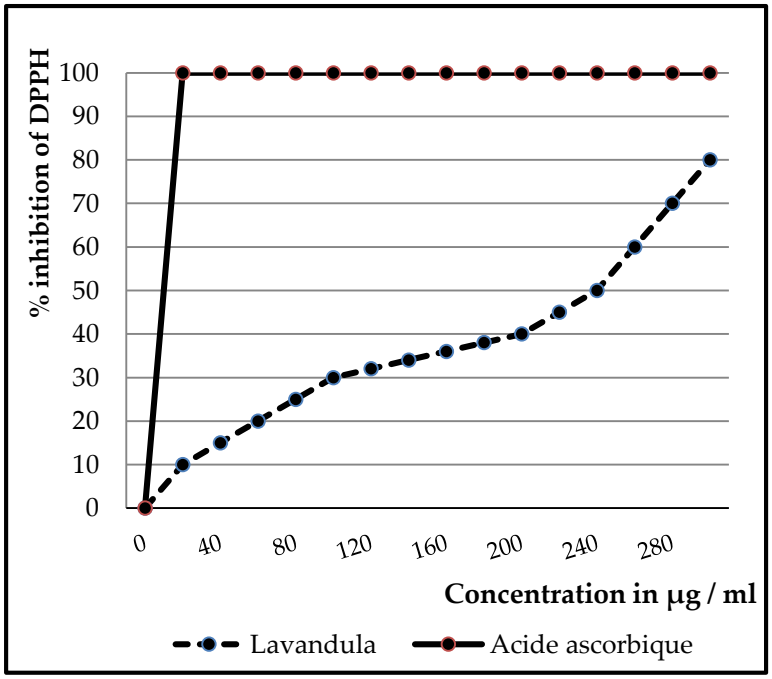

Figure 4. Inhibition of DPPH by ascorbic acid and extract of lavender.

3.4.3. extract Fractions of flavonoids

The development of the inhibition of the free radical DPPH by the different flavonoid fractions of Lavandula is represented in figure 5.

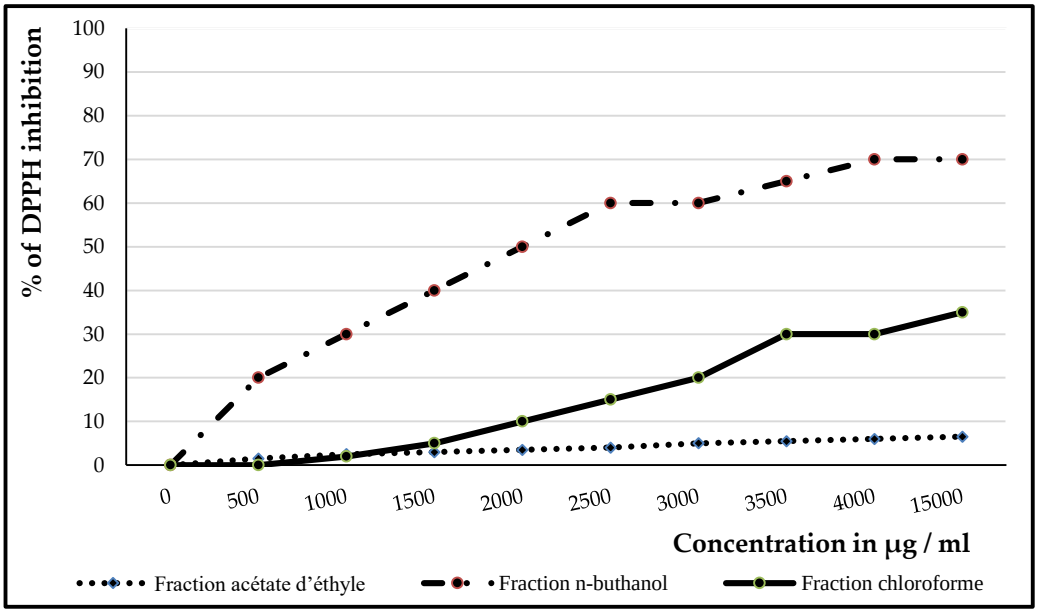

Figure 5. Inhibition of DPPH by Fraction ethyl acetate, fraction n-butanol and fraction chloroform.

3.4.4. Fixed oils

The results presented in Figure 6 illustrate the anti-radical activity of the fixed oils of Lavender.

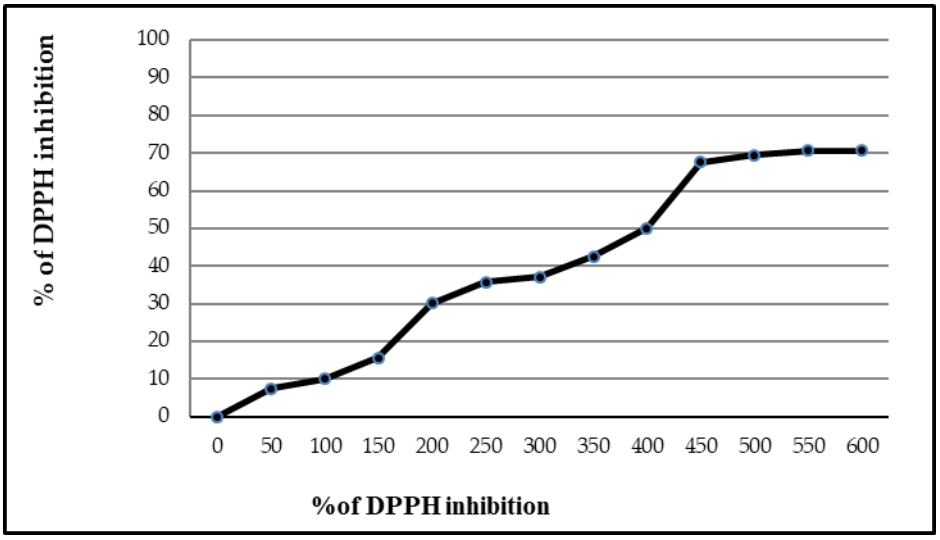

Figure 6. Inhibition of DPPH by fixed oils of Lavender.

4. Conclusion

In the world, especially in Morocco, many researches and studies have been conducted to investigate the pharmaceutical virtues of various aromatic and medicinal plants, as well as the methods of their use, also the conditions of their use and valuation. Most studies have confirmed that lavender (Lavandula angustifolia) is one of them. However, no study has confirmed that lavender is present in the central Middle Atlas, knowing that it can be granted with certain characteristics due to its endemic nature. It is with the objective of verifying this hypothesis that this research work has begun with a view to conducting ecological and pharmacological studies on the lavender of the Dayet Aoua region. And this, to value this aromatic and medicinal plant . The chromatographic analysis highlights the major components of the essential oil of lavender. Monoterpenols are represented by a dominance of linalool (33.74% to 38.74%). Monitoring monoterpenols by noting the abundance of linalyl acetate followed by camphor. The variations in the qualitative and quantitative chemical composition of our sample compared to some previous work may be due to certain ecological factors, the part of the plant used, the age of the plant and the period of the vegetative cycle or even to genetic factors. Concerning the antibacterial activity The essential oil Lavandula angustifolia showed a strong activity against five bacterial strains tested The average of the minimum inhibitory concentration of the EO of lavandula angustifolia varies between 0.332 mg / ml against Staphylococcus aureus and 1.273 mg / ml against Pseudomonas aeruginosa. In terms of antifungal activity, an exhaustive analysis of the data collected shows the antifungal potential of the essential oils of lavender against A. alternata, B. cinerea and F. oxysporum; the B. cinerea strain seems to be the most sensitive to these HEs compared to the other strains represented by F. oxysporum and A. alternata. Eventually, according to the results of the study, it is very clear that Lavandula fixed oils are an anti-radical activity by inhibiting DPPH, and this activity increases as a function of concentration. In fact, they reached an inhibition of 20%, 40%, 70% at concentrations of 150, 350, 600 mg / ml respectively. These results lead us to unequivocally emphasize that the type of plant lavandola Angostofolia found in Dat Awa is a plant that has many virtues and therefore must be valued and protected from the perspective of green chemistry and sustainable development.

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