Efficacy of the Crude Extract and Solvent Fractions of *Lavandula stoechas* L. for Potential Antibacterial and Antioxidant Capacity: An Endemic Medicinal Plant from Algeria

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Summary

This study aims to assess the antioxidant, antibacterial activity, the total phenolics (TPC) and flavonoid content (TFC), as well as the phenolic composition of the aerial parts of *Lavandula stoechas* L. Extraction of flavonoids was carried out by 85% of methanol, then the crude extract was successively separated with ethyl acetate, butanol, and water. The TPC was established to be ranged from 188.29 ± 1.98 to 37.01 ± 0.68 mg GAE g^{-1} DW. Likewise, tested fractions exposed a wide range of flavonoid contents altering between 91.04 ± 1.91 to 13.94 ± 0,31 mg CE g^{-1} DW. The antioxidant properties of *Lavandula stoechas* extract were assessed using the 2,2-diphenyl-1-picryl-hydrazyl-hydrate (DPPH) and ferrous reducing antioxidant activity procedures. Ethyl acetate extract demonstrated a high ability for scavenging DPPH free radicals (14.70 ± 1.59 µg mL^{-1}) and the butanolic fraction displayed strong potential for iron chelation (71.61 ± 2.39 µg mL^{-1}). Antibacterial potential of the *Lavandula stoechas* was tested against six pathogenic bacteria using the disc-diffusion technique and broth dilution test. In addition, minimum bactericidal concentrations (MBC) were employed to ascertain the antibacterial activity. The analyzed extracts further exposed a wide spectrum range of antibacterial behavior against bacterial strains analyzed in the study. The ethyl acetate extract had the strongest activity and was effective fraction with sector of inhibition zone and the little MIC of 35 mm and 0.31 mg/ml respectively against *Staphylococcus aureus*. Prepared extracts were also analyzed for the content of individual phenolic compounds by HPLC method. P-coumaric acid, caffeic acid, myricetin and catechin were identified in extracts. The *Lavandula stoechas* extracts can be related as one of outstanding promising sorts for natural plant source of antioxidant and antimicrobial agents.

Key words

antibacterial capacity, antioxidant capacity, flavonoids, polyphenols, HPLC

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Introduction

In several parts of the globe, conventional medical practice has been recognized for decades for the care of different human foods. The prime reasons of mortality and morbidity comprise widespread infectious diseases and are annually explicitly responsible for 26 % of the world's deaths (Radulovic, 2013; Morens et al., 2008). The treatment of different bacterial infections has been revolutionized by the use of antibiotics. However, their indiscriminate use has contributed to a disturbing rise in microorganisms' antibiotic resistance (Daljit and Gurinder, 2007). Recently, the adoption of herbal medicine as an alternative to available antibiotics has prompted researchers to explore the antimicrobial function related to medicinal plants.

Several studies have shown that plant extracts as antioxidant agents have great potential. The investigation of natural antioxidant molecules which serve as scavengers of free radicals is also of great importance in current research, and the extra production of these radicals may be mischievous for the body. Several cellular elements are destroyed by lipids, proteins, or DNA, causing oxidative stress (Van Acker et al., 1998). However, one of the key food technology challenges is lipid oxidation occurring in food products. It is responsible for the product's rancid smells and tastes, with a consequent decline in nutritional quality and protection (Charalampos et al., 2013).

The genus *Lavandula* is spread in vast areas along the Mediterranean (Ez zoubi et al., 2020). It is a member of the Lamiaceae family and is formed from around 20 evergreen teeny bushes escorted by flowers and aromatic foliage (Allaby, 1992). *Lavandula stoechas* L. is used in cosmetics manufacturing and perfumery productions (Atzei, 2003). Recently, Gilianiet al., (2000) mentioned the activities of antispasmodic, anticonvulsant, sedative properties. Dadaliog and Evrendilek (2004) report that the important oil of *Lavandula stoechas* mostly has poor antibacterial effect. Additionally, it is exploited in folk medicine to treat spasms associated with colic pain and also possesses analgesic, antiseptic, and tranquilizing effects (Nadkarni, 1982; Grzegorezyket al., 2007). Extracts of lavender also have a positive effect on wounds, urinary tract infections, heart disease and eczema (Benabdelkader et al., 2011). It has also been shown that these organisms reduce blood sugar levels (Gilani et al., 2000).

Based on conventional and ethnic botanical uses indicating antimicrobial and antioxidant ability, the plant used in this study was selected. There is, however, little knowledge about the antimicrobial efficacy and chemical composition of this plant. Accordingly, the aim of this work is to screen the performance of antimicrobial and antioxidant activities related to crude extract and their solvent fractions and the chemical composition from aerial parts of the species *Lavandula stoechas* from Mascara west of Algeria.

Materials and Methods

Plant Material, Collection and Extraction

The plant (500 g) was collected from Mascara, Algeria. After drying aerial part from plant material at room temperature, the grinding process was done in a mortar. According to the conventional maceration process conducted at room temperature, 100 g of plant powder was extracted via mixture from methanol/ water with ratio (85:15). There after, the hydro methanolic extract was condensed and dissolved in boiling water under reduced pressure with a rotavapor at room temperature to obtain the crude extract (CrE). After filtration, the solution was parcelled out consecutively with ethyl acetate (EtE), butanol (BtE) and water (WE) (v/v) (Merghemet al., 1995). Solutions with various concentrations were prepared by dilution with DMSO (Dimethyl Sulfoxide) for the antibacterial activity and methanol for the antioxidant potential.

Total Phenolic Content

The total phenolic content (TPC) was determined via the Folin-Ciocalteu reagent (Miliauskaset al., 2004). Every extract (1 mL) was blended about 5 min with 5 mL of 2 N Folin-Ciocalteu reagents. Subsequently, 4 mL of 75 g L^{-1} sodium carbonate (Na_2CO_3) was added. The absorbance related to the reaction mix was measured at 760 nm versus white methanol after undergoing for a period up to 2 h under normal room temperature. Gallic acid was used for calibration curves as a normal. The mean three readings were then used to represent the total phenolic content in milligrams of gallic acid equivalent per gram of dry extract (GAE g^{-1} DE).

Total Flavonoid Content

The total flavonoid content (TFC) was measured using the colorimetric aluminum trichloride procedure ($AlCl_3$) reported by both of Ardetani and Yazdanparast (2007). Every sample (500 µL) was combined to 2 mL of purified water and 150 µL of $NaNO_2$ solution (15%). After 6 minutes, 150 µL of aluminum chloride solution (10%) ($AlCl_3$) was inserted and permitted to be standing for nearly 6 min. The mixture was added to 2 mL of the NaOH solution (4%) and distillation water was immediately applied to the mixture for obtaining 5 mL of solution, thoroughly blended, and left to hold for another period of time up to 15 minutes. A calibration curve of the catechin studied under the same conditions was the measurement of the total flavonoid material. Catechin equivalents were shown to be TFC by gram of dried crop extract (mg CE g^{-1} DE).

Antioxidant Activity Evaluation

DPPH Assay

Antioxidant profile of *Lavandula stoechas* was explored employing by DPPH assay as follows:

1950 µL of 6.10^{-5} M DPPH solution with methanol were mixed with 50 µL from each extract with various concentrations. Under the dark at normal room temperature, the testing tubes were whirlpooled and incubated for a period up to 30 min. The absorption values were then measured with 517 nm using methanol as blank with the spectrophotometer (Shimada et al., 1998). Ascorbic acid and catechin were utilized as a positive control. The inhibition percentage of DPPH radical was assessed as included in this formula:

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

where A_0 is the absorbance of the control for a period 30 min, and A_1 is the absorbance of the tested specimen for a period 30 min.

The DPPH % was graphed versus the specimen concentration, then the logarithmic regression graph examined and determined the magnitude of IC_{50} (inhibitory concentration), which refers to the specimen concentration ($\mu g.mL^{-1}$) required to lessen the value of absorbance of DPPH to 50% of the original value.

Ferric Reducing Antioxidant Power (FRAP) Assay

The FRAP assay was achieved counts on the procedure reported by Oyaizu (1986). Extracts inside 1 mL of methanol were blended with the following compounds: firstly, phosphate buffer (0.2 M, pH 6.6) was inserted by 2.5 mL, second, potassium ferricyanide [$K_3Fe(CN)$] was casted by 2.5 mL. Furthermore, the blend was incubated over a period 20 min under temperature of 50 °C. Afterwards, the amount of 2.5 mL of trichloroacetic acid (10%) was dropped to the blend. Additionally, the whole blend was then centrifuged for 10 min at 3000 turns. Lastly, 2.5 mL top layer of the mixture was blended along with both of 0.5 mL $FeCl_3$ (0.1 %) and also 2.5 mL of distilled water.

The absorption has been estimated at 700 nm and relative to the normal (ascorbic acid and catechin). Rising reaction mix absorption shows rising power reduction. The EC_{50} value ($\mu g.mL^{-1}$) refers to the efficacious concentration that offers absorption of 0.5 to power reduction.

Antibacterial Activity

The antibacterial activity of extacts was done by the agar diffusion assay method (Rios et al., 1988). Six strains from diverse sorts of bacteria were tested: *Escherichia coli* (ATCC 25922), *Staphylococcus aureus* (ATCC 25923), *Pseudomonas aeruginosa* (ATCC 25853), *Salmonella enterica* (clinical isolated), *Streptococcus pneumoniae* (clinical isolated), *Vibrio cholerae* (clinical isolated). Microorganisms were supplied from two roots: the microbiology laboratory (Yessad Khaled Mascara Hospital) and the University of Mascara, Algeria.

The bacteria tested were tailored to 0.5 McFarland turbidity level (10^8 CFU mL^{-1}) and next diluted by ratio 1:100 via sterilized nutrient broth. The composition was completely dissolved in DMSO to get a primary concentrate of stock solving of 10 mg mL^{-1}. In these tests, Gentamicin (10 UI) was employed as empirical positive controls for microorganisms progenies and DMSO/disinfected water (5:95) as negative control for which no inhibitive impact could be noticed.

The Muller-Hinton agar plates are coated by the inoculum (1 mL). Normal sterile empty antibiotic disks (with diameter 6 mm) were imbued via 10 mg mL^{-1} of extracts. The injected disks are slightly pressed into the inoculated agar. The inhibition zone of the petri dishes, developed at the disc center to begin with the microbial increment area, was gauged in milimeters after holding petri dishes for two hours at room temperature to permit the testing drug propagation towards the agar and incubated through a period of 24 h under 37 °C. High antibacterial activity was known to be an inhibition area of 12 mm or more (including disk diameter).

Minimum Inhibitory Concentration (MIC)

MIC values for overall of the isolates were assessed through micro-well dilution process as specified by Akomo et al. (2009). 50 µL of sample solutions (1 mg) in 1% of DMSO were inserted toward the initial rows of microplates and duplicate mitigation of the compositions was conducted by dispensing the mixtures toward their manning wells. 50 µL of suspended culture was injected toward whole, the wells contained broth Muler-Hinton. The micro plates were sealed for 24 hours and were incubated under temperature of 37 °C. The lowest flavonoid concentration was determined and MIC was reported, which completely inhibited macro-growth.

Maximum Bactericidal Concentration (MBC)

100 µL of fluid for each well showing no culture of shift was plated on nutrient agar for the determination of MBC and incubated for 24 h at 37 °C. After this sub subculture was considered MBC, the lowest concentration produced no growth.

HPLC Analysis

A Shimadzu-Prominence-I-HPLC system with LC-2030 pump and photodiode array (PDA: LC-2030 / LC-2040) equipped with a surveyor UV-VIS diode array detection (DAD) and LCQ advantage max ion trap mass spectrometer equipped with an electrospray ionization (ESI) system (from Thrmo fisher scientific, Walthman, MA, USA) was used for intended HPLC analysis. The HPLC column (Supelco, 150 mm x 4.6 mm, particle size 5 µm) and the gradient were implemented for the flavonoids separation. Eluent A was aqueous acetic acid (1%, v/v) and pure methanolacetic acid was a B eluent. The separation was an isocratic stage of 2% B for 2 minutes accompanied by a linearity gradient of 2% to 20% B for 10 minutes and then 100% B for 65 min, and 100% B for 68 minutes, with flow rate of 0.8 $mL.min^{-1}$.

Absorbance spectra were recorded between 190 and 400 nm. The effluent chromatographic stream was directed into the mass spectrometer (MS) interface, electrospray ionisation (ESI). Mass spectrometry data were acquired in the negative ionization mode at 280 nm scanning from 100 to 800 m/z under the parameters as follows: Other mass spectrometer conditions were as follows: drying gas (N2) flow: 1,5 L/min; source temperature: 350 °C; temperature: 300 °C, MS fragmentation energy: 1,4 V; nebulizing gas pressure: 30 psi. The phytochemical identification in the extracts (Fig. 1) was highlighted by the retention times and spectra (UV, MS) compared with data in literature.

Results and Discussion

Total Polyphenol and Flavonoid Content

The findings indicate that the extracts contained high levels of phenols and flavonoids. Total phenolic content ranged from 37.01 mg ± 0.68 mg GAE g^{-1} DW of aqueous extract to 188.29 ± 1.98 mg GAE g^{-1} DW in ethyl acetate extract, which is the richest fraction with the highest determined total phenol content (Table 1). Flavonoids content of the investigated extracts varied from 13.94 ± 0.31 to 91.04 ± 1.91 mg CE g^{-1} DE (Table 1). The highest total flavonoid contents were found in the butanolic extract followed by the ethyl acetate fraction. Moreover, the lowest flavonoid contents was registered in the aqueous extract.

Total flavonoid and phenolic contents tend to be high and vary in extracts of *Lavandula stoechas*. A number of phenolic

compounds are known to generate Lamiaceae species and are used in natural phototherapy (Bruneton, 1993; Chaoucheet al., 2013). The references of the chemical contents of *Lavandula stoechas* are few, with values altering from one specimen to some other. Concerning the hydro methanolic extract, the gained outcome released by Ridouaneet al. (2015) over polyphenol and flavonoid level related to *Lavandula stoechas* extracts from Morocco, we have noted that the contents level in our sample is greater. Again once more, the contents obtained in our study were higher compared to the study of Menaceur and Hazzit (2014).

Table 1. The total phenolic and flavonoids contents of extracts

Medicinal plant	Extracts	Phenols (mg GAE g^{-1} DW)	Flavonoids (mg CE g^{-1} DW)
L. stoechas	CrE	42.23 ± 0.37	36.02 ± 0.51
	EtEe	188.29 ± 1.98	89.52 ± 1.62
	BtE	105.38 ± 2.02	91.04 ± 1.91
	AqE	37.01 ± 0.68	13.94 ± 0.31

Note: GAE g^{-1} DE: Gallic Acid Equivalent per Gram of Dry Extract; CE g^{-1} DE: Catechin Equivalent per Gram of Dry Extract

The variations in phenolic and flavonoid compound content may be due to varying chemistry, extraction methods, collection time, collectivity range and seasonal conditions (Haddouchi et al., 2014).

Antioxidant Activity

The antioxidant potential of the examined *Lavandula stoechas* was assessed via both distinct *in vitro* tests (DPPH and FRAP methods). All the samples ascertained to extremely large antioxidant capacity. It is evident that the ethyl acetate and butanolic fractions have the higher antioxidant activity (14.7 0 ± 1.59 and 19.49 ± 0.41μg mL^{-1} respectively). Remarkable, the ethyl acetate extract exposed a superior DPPH scavenging behavior relative to the reference antioxidant ascorbic acid (18.21 ± 0.67 μg mL^{-1}). Alternatively, a lower performance was noticed for the methanolic and aqueous extracts (67.09 ± 2.25 and 70.19 ± 1,26 μg mL^{-1} respectively).

As opposed to ascorbic acid and catechin, Table 2 indicates the reductive potential of extracts as standards. Methanolic and butanolic fractions were more potent on reducing power compared to aqueous and ethyl acetate fractions. The butanolic extract displayed higher reducing power (EC_{50} = 71.61 μg mL^{-1}) compared to other extracts. Nevertheless, the reduction power for both of ascorbic acid and catechin was higher than other diverse extracts (50.09 ± 0.23 and 47.82 ± 1.01 μg mL^{-1} respectively).

The activity of known antioxidants could be a consequence of the extracted compounds like flavonoids, which according to some research show strong antioxidant activity (Mihaylova et al., 2019; Haraguchi et al., 1992).

Through the present study, the total polyphenols and flavonoids content differ in the diverse fractions, the organic extracts comprise some extra contents that the aqueous extracts don't have.

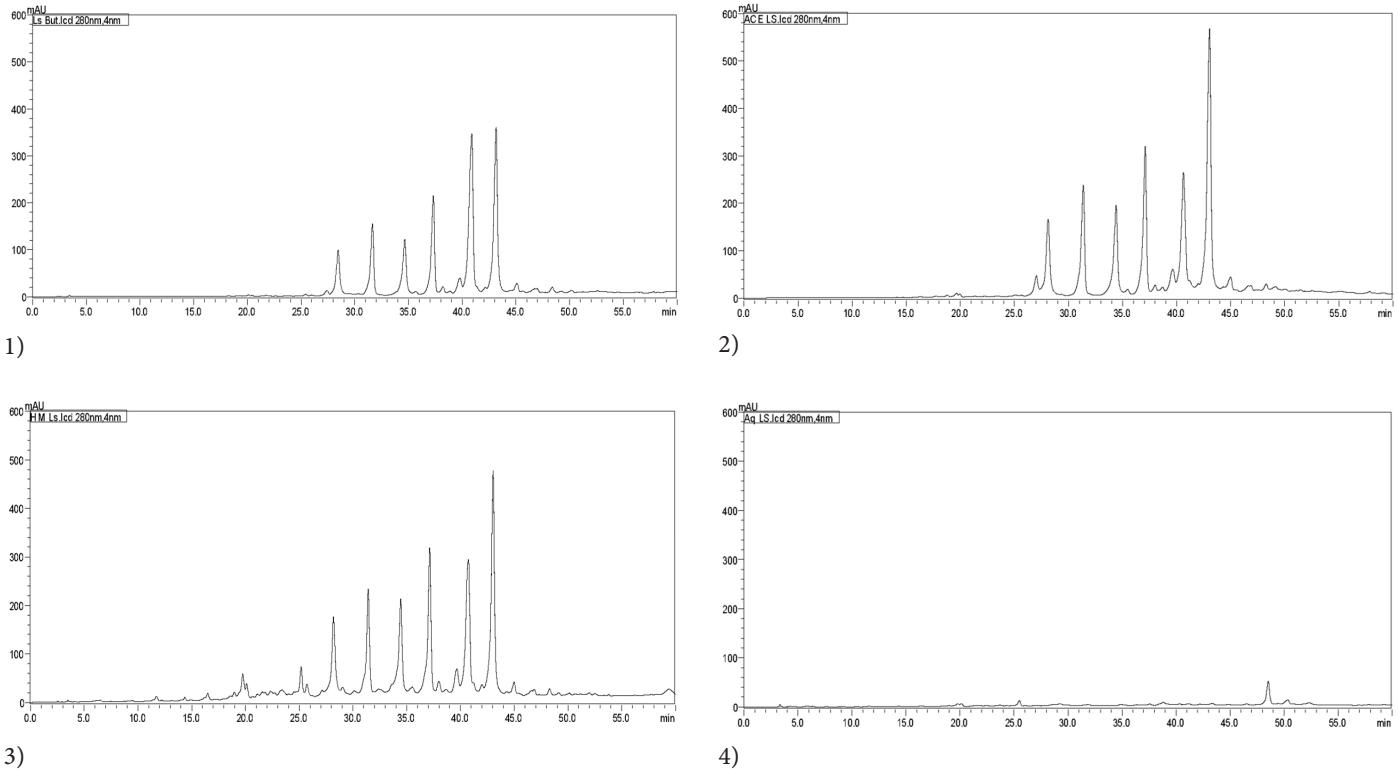

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Figure 1. High activity liquid chromatography profile of *Lavandula stoechas* L. extracts: Butanolic (1), Aqueous (2), Ethyl acetate (3), Hydro-methanolic (4)

Table 2. Antioxidant activity for extracts and standards

Medicinal plant	Extracts	IC_{50} /DPPH (μg ml^{-1})	EC_{50}/Reducing power (μg ml^{-1})
Ajugaiva	CrE	67.09±2.25	88.64± 1.43
	EtE	14.70± 1.59	142.15± 1.56
	BtE	19.49±0.41	71.61±2.39
	AqE	70.19±1.26	653.14±1.14
Standards	Ascorbicacid	18.21 ±0.67	50.09 ±0.23
	Catechin	13.26 ± 0.49	47.82 ±1.01

Note: IC_{50}: inhibition concentration 50%, EC_{50}; effective concentration at which the absorbance was 0.5; CrE - crude extract; EtE - ethyl acetate extract; BtE - butanol extract; AqE - water extract

Through the ferric reduction strength and the ability of organic extracts to spray free and reduce iron, Chekroun et al., (2015) therefore indicate that the rate of polyphenols and free radical spraying activities are associated in a way that allows for free radical reactions and their transformation to stable products.

In alternative studies, the performance of antioxidant activity of *Lavandula stoechas* extracts was exhibited somewhat highly in flavonoids (Ceylan et al., 2015). The total phenolic contents and DPPH IC_{50} values related to *Lavandula stoechas* spp. *luisieri* examined by Baptista et al. (2015) and *L. stoechas* discussed by Menaceur and Hazzit (2014) exhibited linear proportional relation:as the total flavonoid contents increased, DPPH IC_{50} decreased, which is in concord with our result.

The flavonoids' antioxidant depends on its chemical structure according to the literature, particularly of the B-cycle group of 3, 4, 4 and C-cycle group. In the case of flavonols, the C3-type hydroxyl group (quercetin, myricetin, kaemoferol) should be suggested as a crucial site for the free radicals scavenging (Benariba et al., 2013).

Antibacterial Activity

The results of this study revealed that the phenolic compounds extracted from *Lavandula stoechas* showed no reproducible inhibitory effect against *Pseudomonas aerugenosa*. Also the aqueous extract had no effect on all the species studied, exception made for *Streptococcus pneumoniae* with inhibition zone of 4 ± 0.2 mm. However, the ethyl acetate and butanolic extracts were the best compounds to demonstrate antibacterial activity performance contrary to *Staphylococcus aureus* whose sector of inhibition reaches up to 30 mm. Such an important activity of the ethyl acetate fraction against *Streptococcus pneumoniae* (31 ± 1.1 mm)! Yet, the butanolic and ethyl acetate extracts proved an antibacterial effect contrary to *Salmonella enterica* and *Vibrio cholera*. The positive control was dynamic versus the overall 6 organisms analyzed, while 1% DMSO was not dynamic for all the 6 organisms analyzed (Table 3).

The higher efficacy of extracts was confirmed by the lowest inhibitory concentration (MIC) level against the most susceptible bacterial strains (Table4). The effect of concentration related to the efficacious plant extracts is presented in Table 4. The MIC ranged from 0.31 to 10 mg ml^{-1}. *Staphylococcus aureus* was the most sensitive sort (MIC = 0.31 mg mL^{-1}), followed by *Streptococcus pneumonia* (MIC = 0.63 mg mL^{-1}).

In Table 4, the MBC values ranged from 2.5 mg mL^{-1} to 10 mg mL^{-1}. The minimum magnitude of MBC of 2.5 mg mL^{-1} was observed with the ethyl acetate extract on *Streptococcus pneumonia*, which could be attributed to the fact that toechasGram positive organisms have one layer of the cell membrane and are more vulnerable to antibiotics than Gram negative species with a binary membrane and minimum vulnerable to the effects of antimicrobial agents (Kaur et al., 2009).

The effectiveness of the medicinal extracts essentially depends on the extracting solvent used. Organic extracts proved to be more potent in terms of antibacterial properties than the aqueous extracts (Ammer et al., 2016). This indicated the proficiency of the solvents to extract the metabolites according to their polarity or affinity of the phytoconstituents towards the solvent used (Majumder et al., 2019).

In relation to the findings of the total phenolic evaluation and flavonoid contents, the ethyl acetate and butanolic extracts have the highest amount of flavonoids with a high antibacterial capacity.

HPLC Analysis

The chemical analysis by high-performance liquid chromatography (Table 5), revealed the presence of kaempferol 3-O-rutinoside, quercetin-3-O-rhamnoside, catechin-7-O-glucoside, quercetin 3-glucoside, 3-p-coumaroylquinic acid, rosmarinic acid, vanillic acid, luteolin 7-oglucuronide, 4-hydroxybenzoic acid glucoside in all extracts except quercetin 3-glucoside, which was not present in hydromethanolic extract. Caffeic acid derivative, apigenin 6-C-glucoside, apigenin 7-O-glucoside were present only in the hydromethanolic extract.

Considering the HPLC analysis in which 8.347 mg g^{-1} of rosmarinic acid, 0.875 mg g^{-1} of caffeic acid, 1.019 mg g^{-1} of quercetin, and 0.472 mg g^{-1} of rutin were used, it was found that phenolic acids in the extract were predominant over flavonoids.

4-hydroxybenzoic acid glucoside was the major identified compound followed by luteolin 7-oglucuronide, 3-p-coumaroylquinic acid and quercetin-3-O-rhamnoside.

Following the results of this investigation, it was established that compounds isolated from *Lavandula stoechas* may be responsible for part of the antioxidant activity of the total extract and could play an important contribution in the therapeutic efficacy of *Lavandula stoechas.*

Earlier studies stated that caffeic acid, p-coumaric acid, and catechin exhibited a strong effect against *Staphylococcus aureus*, *Escherichia coli*, *Shigella dysenteriae* and *Salmonella typhimurium*. This composition alteratnates the cell membrane permeability and has the capacity to tie the distinct functions of DNA inhibiting cell (Lou et al., 2012; Alves et al., 2013; Kepaet al., 2018).

Salucci et al. (2016) allude that gallic acid possesses a very high antioxidant capacity. In this light, Barzegar (2002) reported earlier that myricetin had a higher reducing capability.

Table 3. Anti-microbial activity for different *Lavandula stoechas* L. extracts in agar diffusion assay. Iinhibition zone diameters (mm)

Strains	Diameter of inhibition zone in mm					
	CrE	EtE	BtE	AqE	Gentamicin	1% DMSO
P. aerugenosa	0.00	0.00	0.00	0.00	4.0 ± 0.2	**NA**
E. coli	15.00 ± 0.32	11.00 ± 0.17	0.00	0.00	16.0 ± 1.5	**NA**
S. aureus	18.00 ± 0.23	35.00 ± 0.460	34 ± 0.37	0.00	30.0 ± 2.0	**NA**
Salmonella enterica	0.00	9.0 ± 0.4	10 ± 1.6	0.00	6.0 ± 0.3	**NA**
Streptococcus pneumoniae	20.00 ± 0.23	31.00 ± 1.1	17 ± 0.48	0.00	29.0 ± 0.8	**NA**
Vibrio cholerae	0.00	12.00 ± 0.76	6 ± 0.32	0.00	4.0 ± 0.5	**NA**

Note: values are obtained count on the mean ± SD (3 replicates); NA = not active; CrE - crude extract; EtE - ethyl acetate extract; BtE - butanol extract; AqE - water extract

Table 4. Antibacterial activity of *Lavandula stoechas* L. extracts as stated by broth microdilution assay

Strains	Methanolic		Ethyl acetate		Butanolic	
	MIC	MBC	MIC	MBC	MIC	MBC
E. coli	5.0 ± 0.7	10	2.5	5	-	-
S. aureus	2.5	10	1.25	5	1.25	5
Salmonella enterica	-	-	5	10	5	>10
Streptococcus pneumoniae	1.25	5	0.31	2.5	0.63	5
Vibrio cholerae	-	-	5	>10	10	>10

Note: MIC- Minimum inhibitory concentration (mg mL^{-1}); MBC - Minimum bacteicid concentration (mg mL^{-1})

Table 5. HPLC-DAD-MS identification of phenolic compounds in *Lavandula stoechas* L. extracts

RT	CrE (µg g^{-1})	EtE (µg g^{-1})	BtE (µg g^{-1})	λ max	MH-	Compounds
19.76	17.47	0	0	283, 325	489	caffeic acid derivative
25.18	18.96	0	0	270, 334	431	apigenin 6-C-glucoside
25.72	9.95	0	0	267, 337	431	apigenin 7-O-glucoside
27.4	0	19.55	6.32	353	463	quercetin 3-glucoside
28.12	68.34	75.73	62.84	345	593	kaempferol 3-O-rutinoside
31.64	76.28	94.13	86.37	256, 352	447	quercetin-3-O-rhamnoside
34.44	91.83	88.03	81.18	278	451	catechin-7-O-glucoside
37.31	105.97	120.96	117.03	310	337	3-p-coumaroylquinic acid
38.21	13.53	10.63	10.37	288, 329	359	rosmarinic acid
39.79	27.02	30.42	25.47	289	409	vanillic acid.
40.89	124.01	134.44	242.74	269, 346	461	luteolin 7-oglucuronide
43.15	215.61	314.08	246.34	256	301	4-hydroxybenzoic acid glucoside

Note: RT - retention time; CrE - crude extract; EtE - ethyl acetate extract; BtE - butanol extract

Conclusion

This study is about the aerial part of *Lavandula stoechas* that grows spontaneously in the west of Algeria. It is concluded that some of the extracts possess strong antibacterial activity and have a good potential for therapeutic uses against some pathogens. *p*-coumaric acid and myricetin have been determined by HPLC analysis in all the plant extracts. The obtained results indicate that the analyzed plant extracts may become important, cheap and noticeable sources for bioactive compounds, comprising phenolic compounds, with antioxidant and antibacterial capacity and may have potential use in medicine and the food industry. Furthermore, studies on the isolation of active ingredients and determination of cytotoxicity of *Lavandula stoechas* are warranted.

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