Antimicrobial Activity of Phenolic Extracts of *Juniperus phoenicea* and *Glycyrrhiza glabra* from Western Algeria

Kheira Zerrouki[1]*, Ali Riazi[1]

[1]Laboratory of Beneficial Microorganisms, Functional Foods, and Health, Faculty of Natural Sciences and Life, University of Mostaganem, Site 3- Ex ITA. Mostaganem 27000. Algeria.

ABSTRACT

The main focus of this study was the antimicrobial effect of 2 medicinal plants that belong to the Algerian Mediterranean flora, *Glycyrrhiza glabra* and *Juniperus phoenicea,* The phenolic extracts of *Glycyrrhiza glabra* and *Juniperus phoenicea* gave respective yields of 56.15% and 47.40% with methanol/water 70% (v/v). A yield of 52.45% and 42.30% was obtained with ethanol/water 70 % (v/v). Total phenolic results showed that in both plants, the hydroethanolic extract was richer than hydroethanolic extract represented by 122.88±6.64 mg Galic Acid equivalent (GAE)/g dm and 120.54±3.35 mg GAE/g ms. The total flavonoids were about 15.48±4.97 and 14.01 ±8.57 mg EQ/g for *J. phoenicea* and *G. glabra*, respectively. Antimicrobial activity results showed that hydromethanolic extract of *J. phoenicea*, *G. glabra,* and their combination was more active against *Staphylococcus aureus* ATCC 33862, whereas they were completely inactive against *Pseudomonas aeruginosa* ATCC 2785, *E. coli* ATCC 25922, and *C. albicans* ATCC 10231. MBC and MIC were 80 and 10 mg/ml for *J. phoenicea* hydromethanolic extract, 20 and 80 mg/ml for *G. glabra* hydroethanolic extract, and 2.5 and 20 mg/ml for combined extract, respectively.

Key Words: *Juniperus phoenicea, Glycyrrhiza glabra, Phenolics, Antimicrobial activity*

eIJPPR 2021; 11(5):18-24

HOW TO CITE THIS ARTICLE: Zerrouki K, Riazi A. Antimicrobial Activity of Phenolic Extracts of *Juniperus phoenicea* and *Glycyrrhiza glabra* from Western Algeria. Int J Pharm Phytopharmacol Res. 2021;11(5):18-24. https://doi.org/10.51847/CUNIhT0KbT

INTRODUCTION

The last decade has seen a rapid increase in research in the field of phytotherapy. Unlike synthetic antibiotics, herbal remedies work not only against bacteria but also viruses and fungi [1].

Infection with bacteria resistant to antibiotics increases every year and the number of people who die increases as a direct consequence of these infections. This is what we call antibiotic resistance [2]. In addition, antimicrobial chemicals that can act effectively on eukaryotic cells, such as yeast, are not available [3].

Many modern medicines use compounds discovered in plants and many current medicines are derived from plant materials. However, the big difference between herbal medicine and modern medicine is that while modern medicine is based on a single molecule,

Nature has endowed each plant with a range of active components that work in synergy to produce a healing effect that cannot be reproduced by a single product [4].

many studies have been able to demonstrate the biological activity and therapeutic modes of action of metabolites extracted from plants. These allow treatment to be approached comprehensively and less aggressively by eliminating most of the side effects known in certain so-called modern drugs [5].

Phenolic compounds are attracting considerable interest in the food, chemical, and medical fields due to their promising antioxidant potential [6].

Antibiotic resistance has become a public health problem around the world especially in terms of foodborne illnesses and nosocomial infections. The valorization of medicinal plants to exploit their extracts or their active ingredients, therefore, represents enormous economic potential.

Corresponding author: Kheira Zerrouki
Address: Laboratory of beneficial microorganisms, functional foods, and health, Faculty of Natural Sciences and Life, University of Mostaganem, Site 3- Ex ITA. Mostaganem 27000. Algeri.
E-mail: ✉ kheirazerrouki.dz@gmail.com
Received: 29 June 2021; **Revised:** 22 September 2021; **Accepted:** 27 September 2021

Current research into the therapeutic effects of plant extracts has revealed several effects of great importance to modern medicine, pharmacy, and industry.

Our work is part of the promotion of products naturally synthesized by medicinal plants. We will attempt to assess the biological and pharmacodynamic effects of organic extracts from two Algerian medicinal plants known for their strong medicinal power.

The present study was carried out in the educational biochemistry and microbiology laboratories at the University of Abdelhamid Ibn Badis in Mostaganem. In this experimental study, we considered two aims:

The first aim is to extract and assay phenolic compounds from two medicinal plants Juniperus phoenicea and Glycyrrhiza glabra. In second, we were interested in the study of antimicrobial activity of the polyphenols of Juniperus phoenicea and Glycyrrhiza glabra alone and combination on microbial species known for their high pathogenic effect.

MATERIALS AND METHODS

Plants origin and preparation

In our study, we used two Algerian medicinal plants, Juniperus phoenicea (Juniper) **(Figure 1)** and Glycyrrhiza glabra (Licorice) **(Figure 2)**. We have used leaves and fruits (cones) of Juniperus phoenicea which were harvested during February 2019 from the region of Ain Nouissy wilaya of Mostaganem. The roots of Glycyrrhiza glabra have been supplied from the same region. All samples were washed to get rid of debris and all kinds of dust, then they were dried in the open air for fifteen days to obtain a better grinding and keep the substances sought-after bioactive.

Figure 1. Dried leaf of J. phoenicea (used in this work)

Figure 2. Dried roots of G. glabra (used in this work)

Extraction and determination of total phenolics

We adopted the protocol described by [7] with slight modifications. 10 g of the powder of the medicinal plants are macerated at room temperature and protected from a light overnight with 100ml of the aqueous solutions: methanol, 70% ethanol (v/v). Filtration was carried out on a piece of muslin fabric, the filtrates were centrifuged at 4000 rpm and room temperature for 20 min. The supernatants were filtered, then concentrated to dryness using a rotavapor. The extracts obtained were stored at 4 °C. The total polyphenol content of the extracts was determined by spectrophotometry according to the colorimetric method by [8].

Results are expressed in mg of gallic acid equivalents per g of dry matter (mg GAE/g dm) according to a gallic acid's calibration curve.

Total flavonoids assay

Flavonoids were determined according to [9] modified by [10]. 0.5 ml of the sample was mixed with 0.5 ml of 2% $AlCl_3$, after 15 min at room temperature, the absorbance of the sample was measured at 430 nm against the blank prepared from the reagent. Each analysis is repeated three times. Results were expressed as mg of quercetin equivalents per g of dry matter (mg QE/g dm).

Preparation of biological material

The microbial strains used to detect the antimicrobial activity of the prepared extracts of *Juniperus phonicea* and *Glycyrrhiza glabra* were original strains from the American Type Culture Collection (ATCC), provided by the LMBAFS laboratory at the University of Mostaganem **(Table 1)**.

Microbial pre-cultures were prepared as described by [11]. Microbial suspensions were prepared 24 hours before inoculation to obtain just confluent colonies. The turbidity was set to 0.5 McFarland that corresponds to 1-2 × 10^8 CFU/ml for bacteria (OD = 0.08-0.1 at 625 nm), 1-5 × 10^6 CFU/ml for *Candida albicans* (OD = 0.12 to 0.15 at

530 nm). Adjusting the inoculum concentration is essential for the quality of the analysis [11, 12].

Antimicrobial activity

The antimicrobial activity test was carried out by two methods: the solid medium diffusion method, in a first step to demonstrate the antimicrobial power of the extracts against the strains used. In the second step, the dilution method in liquid medium (macro-dilution method) was used to measure the minimum inhibitory concentration (MIC) as well as the minimum bactericidal concentration (MBC). The method used is that described by [13, 14].

Table 1. Microbial strains used in this experiment

Strain	Reference
E. coli	ATCC 25922
P. aeruginosa	ATCC 27853
S. aureus	ATCC 33862
C. albicans	ATCC 10231

ATCC: American Type Collection Culture

Solid medium diffusion method

Sterile discs were soaked with 10 µl of each tested extract and placed on the surface of the inoculated medium, then incubated at 37 °C for 24 h for bacteria (*E. coli*, *P. aeruginosa*, *S. aureus*), and 30 °C for 24 h for *C. albicans.* The inhibition diameter was measured in a centimeter. All experiments were repeated in triplicate.

Micro-dilution method

400 µl of each tested extract was dissolved in dimethylsulfoxide (DMSO) then placed in a sterile tube containing 4.6 ml of Muller Hinton broth medium (BMH). A cascade dilution was carried out in a BMH medium to obtain a concentration range between 80 and 0.3 mg/ml [15]. The MIC of the tested extracts on the strain studied is defined as the lowest concentration that inhibits any bacterial growth visible to the naked eye after 18 or 24 h at 37 °C [11].

13 µl of a microbial inoculum, with a density equivalent to 0.5 Mcfarland (10^8 CFU/ml), were placed in each of the tubes in the range and were then incubated at 37 °C for 24 h. Control of the microbial growth, for which 13 µl of the adjusted inoculum were deposited in BMH medium added to DMSO was also carried out.

After 24 h of incubation, the MIC of the tested extracts is deduced from the first tube of the range devoid of microbial growth [15].

The minimum bactericidal concentration (MBC) was determined as follows: The same range of concentration, carried out by MIC technique, was used to determine the CMB of the extracts. Samples were taken from each of the tubes devoid of microbial pellet and then deposited "in streaks" on MH agar. The seeded dishes were incubated at 37 ° C for 24 h. The CMB of the extracts was deduced from the streak devoid of bacteria [15].

RESULTS AND DISCUSSION

Variability of molecules extracted from medicinal plants is due to several factors; environmental, geographic and maturation stages of the plant or its components.

Result of the determination of total polyphenols

Total polyphenols amounts of the samples are given in mg GAE/g dm and are reported in **Table 2.** It was determined that phenolic concentrations of the hydromethanolic extracts were about 122.88±6.64 and 120.54±3.35 mg GAE/g dm for *J. phoenicea* and *G. glabra*, respectively.

Hydroethanolic extracts exhibited relatively low phenolic concentrations, about 119.38±7.85 and 110.46±13.34 mg GAE/g dm for *J. phoenicea* and *G. glabra* in the same order **(Table 1)**.

Another work done by [16] on the hydromethanolic extract of Glycyrrhiza glabra and has reported that the concentration of the total polyphenols was 118.75 ± 23.68 mg GAE/g, which is lower than (120.54 ± 3.35 mg GAE/g dm) reported in the present study.

[17] reported a total polyphenol concentration of 201±5.8 mg GAE/g for the hydromethanolic extract of *J. phoenicea*, which was higher than that of the present work (122.88 ± 6.64 mg GAE/g dm).

Flavonoid content

All flavonoid concentrations were calculated from the quercetin calibration range and the results were expressed in mg QE/g dm. Each test was repeated three times as well. Flavonoids concentrations are presented in **Table 2**.

In general, the content of flavonoids is lower compared to the content of total polyphenols. In **Table 2**, the highest flavonoid concentrations were recorded to hydromethanolic and hydroethanolic extract of J. phoenicea (15.48 ± 4.97 mg QE/gms and 6.31 ± 1.30 mg QE/ g dm) respectively. In contrast, a concentration of 14.01 ± 8.54 mg QE/gms was recorded belong to the hydromethanolic extract of G. glabra. The lowest concentration (5.16 ± 3.91 mg QE/g dm) was recorded for the hydroethanolic extract of the same species.

Table 2. Total polyphenol and total flavonoids contents of the various extracts

Extracts	Total polyphenols (mg GAE /g dm)	Flavonoïds (mg QE/g dm)
EHMG	122.88 ± 6.64	15.48 ± 4.97

EHMR	120.54 ± 3.35	14.01 ± 8.54
EHEG	119.38 ± 7.85	6.31 ± 1.30
EHER	110.46 ± 13.34	5.16 ± 3.91

EHMG: Hydromethanolic extract of Juniper (Juniperus phoenicea); EHMR: Hydromethanolic extract of Liquorice (Glycyrrhiza glabra); EHEG: Hydroethanolic extracts of Juniper (Juniperus phoenicea); EHER: Hydroethnolic extract of Liquorice (Glycyrrhiza glabra); QE: Quercetin Equivalent; GAE : Gallic acid Equivalent ; dm: dry matter; ±: standard deviation.

It is clearly shown that the highest content of flavonoids belongs to the species Juniperus phoenicea. This difference in the content of flavonoids is probably related to their structural diversity [18] where they are found both in free form or as glycosides [19, 20]. This is depending on the plant species.

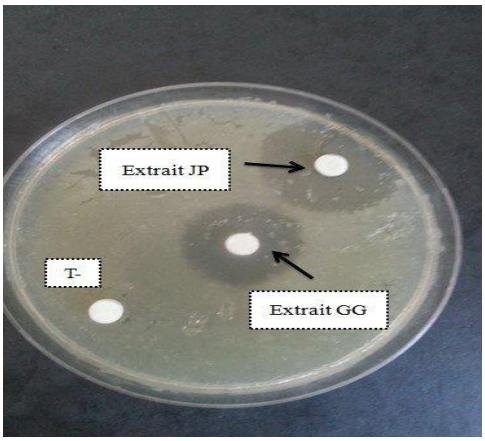
In this study, Glycyrrhiza glabra recorded a concentration of 14.01 ± 8.54 mg QE/g dm of the hydromethanolic extract which is a higher value than (0.012 mg QE/g) reported by [21]. The total flavonoid contents of the methanolic and ethanolic extract of Glycyrrhiza glabra showed a large difference in the values with (14.01 ± 8.54 mg QE/g and 5.16 ± 3.91 mg QE/g) respectively.

Result of antimicrobial activity

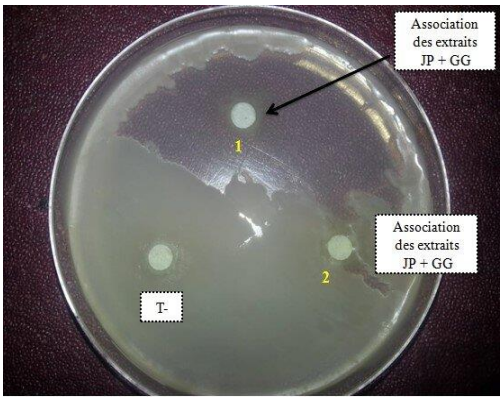
The present study aims to show the presence or absence of antimicrobial activity, against some pathogenic microbial strains, in the presence of phenolic extracts of Juniperus phoenicea and Glycyrrhiza glabra alone and together.

Result of Solid medium diffusion method

The antimicrobial activity was manifested by the appearance of light areas called zones of inhibition around the discs impregnated with the tested extract **(Figure 3)**.



a)



b)

Figure 3. Antibacterial effect of JP and GG extracts against *Staphylococcus aureus*
(a: extracts alone; b: combined extract).
JP: Juniperus phoenicea extract; **GG:** Glycyrrhiza glabra extract; **T-:** Control solution

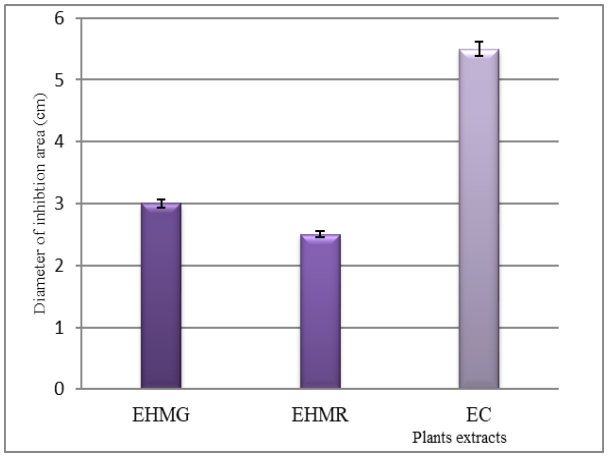


Figure 4. Diameters of inhibition areas obtained by hydromethanolic extracts of Juniperus phoenicea and Glycyrrhiza glabra alone and in combination against *Staphylococcus aureus*.
EHMG: Hydromethanolic extract of Juniper (Juniperus phoenicea); EHMR: Hydromethanolic extract of Liquorice (Glycyrrhiza glabra); EC: Combined extract of Juniper and Liquorice (v/v).

It was observed that the bacterial strain *Staphylococcus. aureus* was very sensitive to the hydromethanolic extracts of Juniperus phoenicea and Glycyrrhiza glabra with diameters evaluated at (3 ± 0.74 cm and 2.5 ± 0.39 cm) respectively. Therefore, the combined extract of the two medicinal plants gave a much greater effect (diameter 5.5 ± 1.52 cm) **(Figure 4)**.

The strains; *Escherichia coli*, *Pseudomonas aeruginosa*, and *Candida albicans* showed resistance to all extracts studied.

The antibacterial effect of active substances from plant origins mainly depends on the type of bacteria, Gram-positive or negative [22, 23].

The tested extracts exhibited variability depending on the strains studied; where we recorded a complete lack of an antimicrobial effect against the strains (*E. coli*, *P. aeruginosa*, and *C. albicans)*, while *S. aureus* was very sensitive.

As for the hydromethanolic extract of Juniperus phoenicea, the results obtained indicated a significative inhibitory effect ($p \leq 0.05$) against *Staphylococcus aureus* with a diameter inhibition area of 3 ± 0.74 cm. These results are consistent with the results of [24, 25] both have studied phenolic extract effect.

Further studies have been carried out about antibacterial activity against *Staphylococcus aureus* using herbal extracts. The synergistic effects of Daphne genkwa, Verbena Officinalis, Magnolia Officinalis, and Momordica charantia in combination with gentamicin or oxacillin against methicillin-susceptible (ATCC25923) and methicillin-resistant (ATCC43300) *S. aureus* were evaluated. This study identified the bioactive ingredients of plants that potentially have antibiotic effects [26].

On the other hand, no antibacterial activity of this extract was reported against *E. coli* and *P. aeruginosa*. The extraction method and the nature of the solvent can influence the antibacterial activity of the phenolic compounds of J. phoenicea [22].

No antifungal activity of the three extracts was recorded against *Candida albicans*. It is difficult to compare these results with those in the literature because the use of different extraction methods reduces the reliability of the comparison between the studies.

The structural difference makes Gram (+) bacteria more sensitive to various natural compounds such as plant extracts [27].

Certain properties of the outer membrane of Gram-bacteria are also assets against the action of antibacterial agents [28, 29]. Therefore, the combined extract in this study has shown no inhibition against *Escherichia coli* and *Pseudomonas aeruginosa* (Gram-negative). Another study have indicate that the use of α-pinene-/sabinene-rich juniper EO with anti-QS properties along with refrigeration could provide an additional advantage for controlling the spoilage activities of pseudomonads in fish [30].

Macro-dilution method in liquid medium

The macro-dilution method in liquid medium was performed to determine the MIC and CMB of the hydromethanolic extracts of Juniperus phoenicea and Glycyrrhiza glabra alone and in combination against the strain *Staphylococcus aureus*. values of the CMB/MIC ratio were also studied **(Table 4)**.

According to our results illustrated in the table above, the lowest MIC is that of the combined extract
(2.5 mg/ml), followed by that of Juniperus phoenicea extract (10 mg/ml) and finally the hydromethanolic extract of Glycyrrhiza glabra (20 mg/ml). The lowest CMB (2.5 mg/ml) belongs to combined extract, in contrast, the MIC of hydromethanolic extracts of Juniperus phoenicea and Glycyrrhiza glabra is identical (80 mg/ml).

MIC is the lowest concentration of inhibitory antibiotic for which it no longer has visible microbial germs. In addition, the bactericidal effect is an effect manifested by an acceleration of the death of bacteria in vivo or in vitro [11].

It was reported that when the CMB/MIC ratio is <4, the extract is considered to be 'bactericidal' [22].

In the present study, the CMB/MIC ratio of the three extracts is greater than 4, which means that the extracts studied have a bacteriostatic effect against *Staphylococcus aureus.*

G. glabra's pharmacological activities have been largely determined against various parasites and microorganisms, plasmodium falciparum, and viruses. A study results suggesting that a complex mixture of *L. paracasei* HP7 containing P. frutescens and G. glabra extracts may be an alternative to treating diseases caused by *H. pylori* infection [5].

Additionally, it shows anti-inflammatory, antifungal, cytotoxic activities, antioxidant, and anticarcinogenic. In recent study, three active compounds of Gg have the potential to be strong inhibitors for Mpro of SARS-CoV2 but glycyrrhizic acid has a high binding affinity and a good properties [31].

Juniperus extract has a strong antioxidant activity and gastrointestinal effect [32, 33]. *Juniperus phoenica* L. leaves extract has a good protective role against Gamma-irradiation induced Oxidative stress [34, 35].

Table 3. Results of MIC and CMB of tested extracts against *Staphylococcus aureus*.

	MIC (mg/ml)	MBC (mg/ml)	MBC/MIC
EHMG	10	80	8
EHMR	20	80	4
Combined extract	2.5	20	8

EHMG: Hydromethanolic extract of Juniper (Juniperus phoenicea); EHMR: Hydromethanolic extract of Liquorice (Glycyrrhiza glabra)

CONCLUSION

As a Mediterranean country, Algeria is a huge source of active molecules of plant origin. For this effect, the aim of this study was of making a modest contribution to solve problems of resistance developed by microorganisms to antimicrobial agents (antibiotics and antifungals).

Our objective was to assay some bioactive molecules of two medicinal plants belonging to Glycyrrhiza glabra,

Algerian flora, and Juniperus phoenicea, as well as to test the antimicrobial potential of their extracts.

The micro-constituents of plants, of which polyphenols are the main representatives, provide beneficial effects against the development of various pathologies. These molecules are found in plants, from roots to fruit. The hydromethanolic extraction of phenolic compounds from the plant studied has shown the highest yield 56.15% for Juniperus phoenicea and 47.40% for Glycyrrhiza glabra. This is in comparison to hydroethanolic extraction. polyphenols concentrations of the hydromethanol extract of Glycyrrhiza glabra and Juniperus phoenicea gave respective contents of 122.88 ± 6.64 and 120.54 ± 3.35 mg EAG/g dm.

The antimicrobial potential by the method of diffusion on solid medium (aromatogram), showed a great inhibitory effect of the two hydromethanolic extracts of Juniperus phoenicea and Glycyrrhiza glabra against the pathogenic strain *Staphylococcus aureus* ATCC 33862. No inhibitory effect on the other strains studied (*C. albicans* ATCC 10231, *P. aeruginosa* ATCC 27853, and *E. coli* ATCC 25922).

From these results, a study of all chemical compositions of the extracts is necessary to identify and specify the active ingredients and to understand their mode of action In Vitro and In vivo, with the aim of more significant data to practice in clinical trials. These two medicinal plants are receiving increased attention due to their rich composition and use as antibiotic agents.

Acknowledgments: We express deep thanks to Pr. A. Riazi for providing pathogenic strains from his laboratory (LMBAFS) . Our thanks to the searcher N. Amara for her practical help.

Conflict of interest: None

Financial support: The entire work was supported by the faculty of Science, nature and life of the university of Mostaganem in Algeria.

Ethics statement: None

REFERENCES

[1] Siewert AM. Natural antibiotics. Nature's secret weapon. Editions Médicis. Paris, France. 2015. 127p.

[2] Blair JM, Webber MA, Baylay AJ, Ogbolu DO, Piddock LJ. Molecular mechanisms of antibiotic resistance. Nat Rev Microbiol. 2015;13(1):42-51. doi:10.1038/nrmicro3380

[3] Xianghong W, Zhenming C, Lixi Y, Jing L, Meiju L, Longfei W. A marine killer yeast against the pathogenic yeast strain in crab (Portunus trituberculatus) and an optimization of the toxin production. Microbiol Res. 2007;162(1):77-85.

[4] Chevallier A. Medicinal plants, Gründ Editions. 2007. Paris.

[5] Lee HA, Kim JY, Kim J, Nam B, Kim O. Anti-Helicobacter pylori activity of acomplex mixture of Lactobacillus paracasei HP7 including the extract of Perilla frutescens var. acuta and Glycyrrhiza glabra. Lab Anim Res. 2020;36(1):1-8.

[6] Tavares WR, Seca AM. The current status of the pharmaceutical potential of Juniperus L. metabolites. Medicines. 2018;5(3):81. doi:10.3390/medicines5030081

[7] Ivanova DI, Nedialkov PT, Tashev AN, Olech M, Nowak R, Ilieva YE, et al. Junipers of Various Origins as Potential Sources of the Anticancer Drug Precursor Podophyllotoxin. Molecules. 2021;26(17):5179. doi:10.3390/molecules26175179

[8] Singleton VL, Rossi JA. Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. Am J Enol Vitic. 1965;16(3):144-58.

[9] Kim DO, Jeong SW, Lee CY. Antioxidant capacity of phenolic phytochemicals from various cultivars of plums. Food Chem. 2003;81(3):321-6.

[10] Djeridan A, Yousfi M, Nedjmi D, Boutassouna D, Stoker P, Vidal N. Antioxidant activity of some medical plants extracts containing phenolic compounds. J Food Chem. 2006;97(4):654-60.

[11] Ibrahim D, Sewid A, Arisha AH, Abd El-fattah A, Abdelaziz AM, Al-Jabr OA, et al. Influence of Glycyrrhiza glabra Extract on Growth, Gene Expression of Gut Integrity, and Campylobacter jejuni Colonization in Broiler Chickens. Front Vet Sci. 2020;7:612063. doi:10.3389/fvets.2020.612063

[12] Haddouchi F, Zerhouni K, Sidi-Yekhelef A, Chaouche MT. Evaluation of the antimicrobial activity of different extracts of Helichrysum stoechas subsp. Rupestrian. Bull Royal Soc Sci Liège. Cork Liège. Liège. 2016;85:152-9.

[13] Bauer AW, Kirby WM, Sherries JC, Tuck M. Antibiotic susceptibility testing by standardized disc diffusion method. Am J Clin Pathol. 1966;45(4):493-6.

[14] Ananil K, Hudson JB, de Souzal C, Akpaganal K, Towe GH, Amason JT, et al. Investigation of medicinal plants of TOGO for antiviral and antimicrobial activities. Pharm Biol. 2000;38(1):40-5.

[15] Guinoiseau E. Antibacterial molecules derived from essential oils: separation, identification and mode of action. French. Corsica: University of Corsica. 2010; 149 p.

[16] Rahmouni S, Reghis S. Phytochemical study and evaluations of the antioxidant and anti-bacterial

activities of the species: Lavandula steochas, Glycyrrhizza glabra L., Crocus sativus L. and Linum usitassimum L. Master's thesis, University of the Mentouri Brothers, Constantine. Algeria. 2016; 95p.

[17] Raina R, Verma PK, Peshin R, Kour H. Potential of Juniperus communis L as a nutraceutical in human and veterinary medicine. Heliyon. 2019;5(8):e02376. doi:10.1016/j.heliyon.2019.e02376

[18] Bahorun T, Luximon-Ramma A, Crozier A, Aruoma OI. Total phenol, flavonoid, proanthocyanidin and vitamin C levels and antioxidant activities of Mauritian vegetables. J Sci Food Agric. 2004;84(12):1553-61.

[19] Pietta PG. Flavonoids as antioxidants. J Nat Prod. 2000;63(7):1035-42.

[20] Heim KE, Tagliaferro AR, Bobilya DJ. Flavonoid antioxidants: Chemistry, metabolism and structure-activity relationships. J Nutri Biochem. 2002;13(10):572-84.

[21] Alioui K. Phytochemical study and evaluation of the antibacterial and antioxidant activity of two extracts of the plant Glycyrrhiza glabra L. Master's thesis, Abou-Bekr Belkaïd University, Tlemcen. Algeria. 2016; 63p.

[22] Liu J, Dehbi M, Moeck G, Arhin F, Bauda P, Bergeron D, et al. Antimicrobial drug discovery through bacteriophage genomics. Nat Biotechnol. 2004;22(2):185-91.

[23] Vara M. Polymyxin Derivatives that Sensitize Gram-Negative Bacteria to Other Antibiotics Molecules. 2019;24(2):249. doi:10.3390/molecules 24020249

[24] Hayouni EA, Abedrabba M, Bouix M, Hamdi M. The effects of solvents and extraction method on the phenolic contents and biological activities in vitro of Tunisian Quercus coccifera L. and Juniperus phoenicea L. fruit extracts. Food Chem. 2007;10:10-6.

[25] Polumackanycz M, Kaszuba M, Konopacka A, Urszula Marzec- Wróblewska U, Wesolowski M, Waleron K, et al. Phenolic Composition and Biological Properties of Wild and Commercial Dog Rose Fruits and Leaves. Molecules. 2020;25(22):5272. doi:10.3390/molecules 25225272

[26] Kuok CF, Hoi SO, Chan CH, Fong LH, Cheong-Kei Ngok CK, Meng LR, et al. Synergistic antibacterial effects of herbal extracts and antibiotics on methicillin-resistant Staphylococcus aureus. A computational and experimental study. Exp Biol Med (Maywood). 2017;242(7):731-43.

[27] Noureddine T, El Husseini Z, Nehme A, Abdel Massih R. Antibacterial activity of Ilex paraguariensis (Yerba Mate) against Gram-positive and Gram-negative bacteria. J Infect Dev Ctries. 2018;12(9):712-9. doi:10.3855/jidc.10380.

[28] Wax RG, Lewis K, Salyers A, Taber H. Bacterial resistance to antimicrobials. 2nd edition. CRC Press, Florida, USA; 2008. 448p.

[29] Zouari Bouassida K, Makni S, Tounsi A, Jlaiel L, Trigui M, Tounsi S. Effects of Juniperus phoenicea Hydroalcoholic Extract on Inflammatory Mediators and Oxidative Stress Markers in Carrageenan-Induced Paw Oedema in Mice. Hindawi BioMed Res Int. 2018;2018. doi:10.1155/2018/3785487

[30] Myszka K, Tomaś N, Wolko Ł, Szwengiel A, Grygier A, Nuc K, et al. In situ approaches show the limitation of the spoilage potential of Juniperus phoenicea L. essential oil against cold-tolerant Pseudomonas fluorescens KM24. Appl Microbiol Biotechnol. 2021;105(10):4255-68. doi:10.1007/s00253-021-11338-3

[31] Srivastava V, Yadav A, Sarkar P. Molecular docking and ADMET study of bioactive compounds of Glycyrrhiza glabra against main protease of SARS-CoV2. Mater Today Proc. 2020. doi:10.1016/j.matpr.2020.10.055

[32] Gaber El-Saber B, Magdy Beshbishy A, El-Mleeh A, Abdel-Daim MM. Traditional Uses, Bioactive Chemical Constituents, and Pharmacological and Toxicological Activities of Glycyrrhiza glabra L. (Fabaceae). Biomolecules. 2020;10(3):352.

[33] Salvà- Catarineu M, Romo A, Mazur M, Zielińska M, Minissale P, Dönmez A, et al. Past, present, and future geographic range of the relict Mediterranean and Macaronesian Juniperus phoenicea complex. Ecolo Evol. 2021;11(10):5075-95.

[34] Dessoky ES, Ismail I, El-Hallous E, Alsanie WF. Protective Role of Juniperus phoenicea L. Leaves Extracts against Gamma-irradiation-induced Oxidative Stress. J Biol Sci. 2020;23(7):922-30.

[35] Al-Ghamdi M, Aly MM, Sheshtawi RM. Antimicrobial Activities of Different Novel Chitosan-Collagen Nanocomposite Films Against Some Bacterial Pathogens. Int J Pharm Phytopharmacol Res. 2020;10(1):114-21.