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Research Article

Phenolic compound profile, and evaluation of biological properties of *Bassia muricata* (L.) Asch. aerial part

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Abstract: Current study verifies the biological efficiency of *Bassia muricata* (Chenopodiaceae $_{vent}$), a wild plant in the Algerian desert. MeOH extract (70%) of the aerial parts of *B. muricata* was tested for antibacterial, anti-inflammatory and antioxidant activities. In addition to determining the value of the SPF and its effectiveness as hypoglycemia through a glucose uptake assay by yeast cells. Its phenolic content was also verified by quantitative estimations and RP-HPLC-UV analysis. MeOH extract of *B. muricata* exhibited antioxidant effects, where it showed good to moderate free radical inhibition activity towards both $DPPH^{\bullet}$ and $OH^{\bullet}$, and this corresponded with excellent anti-hemolytic activity. As well as being a Fe^{2+} and molybdate reducing agent, the extract showed moderate photoprotective activity with $SPF_{Spectrophootometric}=18.89\pm0.005$. It also has anti-inflammatory properties and enhances glucose uptake. MeOH extract of *B. muricata* showed remarkable antibacterial activity against *B. subtilis*, *L. innocua*, *S. aureus*, *E. coli* and *P. aeruginosa*. It did not give efficacy against *S. typhimurium*. Its phenolic content on the other hand was verified by quantitative estimations and RP-HPLC-UV analysis, which revealed the presence of chlorogenic acid, *p*-coumarin acid, gallic acid as a major phenolic compounds.

These results showed that *B. muricata* could be useful as source of bioactive compounds for food, the pharmaceutical industry and the manufacture of cosmetics.

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1. INTRODUCTION

The species *Bassia muricata* (L.) Asch. is a sandy annual plant that belongs to the Chenopodiaceae family and its synonyms are *Salsola muricata* L., or *Kochia muricata* L. (Turki *et al.*, 2008), and locally known as Ghabitha. It is distributed in the dry regions in Saharo-Arabian, North Africa, and Iran (Bouaziz *et al.*, 2009). This medicinal plant whose leaves and aerial part have been reported to have medicinal significance in the traditional system of

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medicine. In Algeria it is used for diarrhea and skin diseases, specifically to treat dermatosis, pustules, boils, and infected wounds (Hammiche & Maiza, 2006). In Morocco, it is an antidiabetic (Boufous *et al.*, 2017). In Saudi Arabia, seed oil is used in the treatment of sores (Awad, 2017). Also mentioned that it is used as an antipyretic, analgesic, and against spasticity, hypotension, and kidney disease (Mohammedi *et al.*, 2019). Previous biological activities studies have proven that it possesses antioxidants, antimicrobials, and insecticidal properties (Bouaziz *et al.*, 2009; Chemsa *et al.*, 2016; El-Sayed *et al.*, 1998).

This plant was chosen in this study because it is one of the most widespread types of plants in the north of the Algerian desert, in addition to being a rich source of active compounds, as stated through quantitative estimates in previous researches. As it was able to isolate two types of phenolic compounds (Quercetin-3-*O*-(6″-feruloyl)-sophoroside and quercetin-3-*O*-(6″-caffeoyl)-sophoroside) from its aerial part during the previous work of researchers Kamel *et al.* (2001). Shaker *et al.* (2013) were able, in their research, to purify three metabolites a flavonoid glycoside (3-O-[α-L-arabinopyranosyl-(1→2)-L-α-arabinopyranosyl)]-3′-methylquercetin), and 3′-methylquercetin, 3,4-dimethoxytoluene.

The first objective of this work is to investigate the phenolic active compounds of the MeOH extract of the aerial part of *B. muricata*. The second is to determine its biological efficiency as antioxidant, antimicrobial, antidiabetic, anti-inflammatory, and a sun protection agent, in order to reach natural products with pharmaceutical and cosmetic properties. Thus, this work is considered the first of its kind, as it includes the study of a group of biological properties of this medicinal plant. It also includes an RP-HPLC-UV analysis of the MeOH extract of *B. muricata* growing in the Algerian desert.

2. MATERIAL and METHODS

2.1. Plant Material and Preparation of The Extract

B. muricata (aerial part) was collected in March 2020, from Debila district (33º29'N,6º56'E) El Oued, Algeria, and identified by Pr. Noureddine Slimani, Department of Biology, University of El Oued, Algeria. The sample was washed with cold water, dried, and crushed. The sample powder (20g) was extracted by maceration of 100mL methanol (methanol/water: 70/30%) for 24 h at room temperature. After filtration, the process was repeated three times and the extracts were collected and then concentrated using Rotavap at a temperature of 40°C and stored at 4°C.

2.2. Chemical Analysis of Phenolic Compounds

2.2.1.*Colorimetry of phenolic compounds*

Total phenolic contents (TPC) of extract were examined using the Folin Ciocalteu method, according by Guha *et al.* (2010), with some modifications. Briefly, 0.2mL of sample and 1mL of 10% Folin Ciocalteu reagent were incubated for 5 min, after which 0.8mL of 7.5% Na_2CO_3 solution was added to the solution. It was incubated for 40 min in the dark and at room temperature. Absorbance was measured at 765 nm. The TPC was calculated according to the equation that was obtained from the calibration standard gallic acid graph y=0.006x+0.0007, R^2=0.99. TPC of the extract was expressed as µg GAE/mg dry extract.

Total flavonoid contents (TFC) were estimated using the Colorimetric method reported by Muthukrishnan *et al.* (2018). The absorbance was measured at 415 nm. Use Quercetin (Q) as a standard. The TFC were expressed as µg of quercetin equivalents 1mg of dry MeOH extract (y=0.005x+0.0402, R^2=0.99).

Hydrolyzable tannins contain (HTC) was estimated using the Folin-Denis method reported by Kousalya and Jayanthy (2016). The absorbance was read at 700 nm. HTC of the extract was expressed as a gallic acid equivalent (µg GAE/mg). Using equation y=0.016x-0.025, R^2=0.98.

The total Condensed tannins (TCT) of the extracts were assayed according to the vanillin-HCl method modified by Muthukrishnan *et al.* (2018). In brief, the extracts 0.5mL were mixed with 3mL of vanillin reagent (4%, w/v in methanol) in aluminum-coated test tubes and 1.5mL of 1N HCl and mixed well. The tubes were incubated at 20°C for 15 min. Afterward, absorption was measured at 500 nm. Results were expressed as µg catechin (C) equivalents mg of extract. TCT were obtained from the regression equation of the catechin's calibration curve ($y=0.0036x + 0.0249$, $R^2=0.996$).

Anthocyanin content (AC) was determined according to the pH differential method (Lee *et al.*, 2005). Briefly, 0.4mL of the extract was mixed with 3.6mL of KCl buffer (0.0025M, pH=1) and CH_3COONa buffer (0.4M, pH=4.5) was added each one by one. After incubation for 30 min, the absorbance was read using a spectrophotometer at wavelengths of 700 nm and 510 nm. By applying the following equation, AC was expressed in µg equivalent to cyanidin-3-glucoside per mg of the plant extract.

$$\text{Anthocyanin pigment (µg C-3-GE/mg)} = \frac{\frac{A \times MW \times DF \times 100}{MA}}{100}$$

where: $A=(A_{510}-A_{700})pH_1-(A_{510}-A_{700})pH_{4.5}$. MW; cyanidin-3-glucoside molecular weight (449.2g/mol). DF; dilution factor. MA; molar extinction coefficient of cyanidin-3-glucoside (26.9l/mol.cm).

2.2.2. *Analysis of phenolic compounds by RP-HPLC*-UV

The analytical RP-HPLC-UV system was used for both qualitative and quantitative analyses of individual phenolic compounds. Chromatographic separations were performed on Shim-pack VP-ODS C18 (250mm×4.6mm, 5µm) column at a temperature of 25°C. The mobile phase consisted of acetonitrile and ultrapure water. The flow rate was 1mL/min, and the injection was 20µL. The monitoring wavelength was 268 nm. The identification of phenolic compounds of plant extract was based on retention time and spectral matching with nine standards shown in Table 2.

2.3. Antioxidant Activity

DPPH• free radical scavenging assay was estimated by determining the IC_{50} value. It is the concentration of the extract capable of inhibiting 50% of DPPH• free radicals. The protocol reported by Jafri *et al.* (2017) was followed. The same volume of sample and 0.1mM of DPPH• solution was mixed and incubated at room temperature in the dark for 30 min. Absorbance was measured at 517 nm. In this test, ascorbic acid was used as the standard compound. The percentage DPPH• radical scavenging potential was measured using:

$$\text{\% of DPPH}^{\bullet}\text{ radical scavenging activity} = (DO_{Control} - DO_{Sample}/DO_{Control}) \times 100$$

Where $DO_{Control}$ and DO_{Sample} are the absorbance of the control and test samples, respectively.

The scavenging activity of the extract against the hydroxyl radical (OH•) was determined by following the method described by Guo *et al.* (2011), with some modifications. 1mL of 1.5mM $FeSO_4$, 0.7µL of 6mM H_2O_2, 0.3µL of 20mM salicylic acid were added and 1mL of the extract was added. Absorbance at 510 nm was determined after 60 min of cuddling at room temperature. The percentage scavenging activity was calculated by using the following equation:

$$\text{\% of HO}^{\bullet}\text{ radical scavenging activity} = [1-(DO_{Sample})/ DO_{Control}] \times 100$$

IC_{50} value is the effective concentration at which OH• were scavenged by 50%.

The anti-hemolysis activity of the extract was determined *in vitro* by applying the steps described by Afsar *et al.* (2016), with some additions. The extract (2ml) was incubated for 5 min at 37°C with 40µl of 10% human red blood cell (RBC) suspension. After incubation, 40µL of 30µM H_2O_2, 40µL of 80mM $FeCl_3$ and 40µL of 50mM ascorbic acid were respectively added and the mixture was incubated for 1 h at 37°C. Then the mixture was centrifuged (700 rpm, 5 min). Absorbance was read at 540 nm, was calculated of hemolysis percentage according to the following equation:

$$\% \text{ of Hemolysis}=[DO_{Control} / DO_{Sample}]\times 100$$

Hly_{50} is a value that represents the concentration at which 50% RBCs were lysed.

Ferrous reducing power of the extract was performed using the method of Jafri *et al.* (2017), as follows: In a test tube 0.5mL of the extract was added, 1.25mL phosphate buffer (0.2M, pH=6.6) and 1.25mL 1% $K_3Fe(CN)_6$. The tubes were placed in a water bath for 20 min at 50°C after which 1.25mL of 10% TCA was added to the solution. The solution was centrifuged for 10 min at 3000 rpm. That 1.25mL of supernatant was taken and mixed with 1.25mL of distilled water and 0.25mL of 0.1% $FeCl_3$. The absorbance was measured at 700 nm. EC_{50} is defined as the effective concentration of the extract that provides an absorbance of 0.5 at 700 nm.

The total antioxidant capacity (TAC) of the extract was expressed as gallic acid equivalent (µg GAE/mg ED); where the estimation was based on the method of phosphomolybdate (Jafri *et al.*, 2017). 0.1mL of the sample was mixed with 1mL of molybdate solution and then incubated in a water bath for 1h at 95°C. After cooling the tubes, the absorption was read at 695 nm.

2.4. Determine of Sun Protection Factor (SPF)

The photoprotective activity of the extract was tested by calculating SPF by applying the following equation, after measuring the absorbance of a sample dissolved in ethanol (1mg/mL) at seven different wavelengths (290-320 nm) (Mansur *et al.*, 1986):

$$SPF_{\text{Spectrophootometric}}=CF\times\sum_{290}^{320} \times EE(\lambda)\times I(\lambda) \times DO(\lambda)$$

where: CF; correction factor (10). EE; erythemogenic effect of radiation with wavelength (λ) nm. I; solar intensity spectrum (λ) nm. DO (λ); spectrophotometric absorbance values at wavelength. The values of EE(λ)×I(λ) are constants.

In this test, Avene® sunscreen was used as a positive control.

2.5. *In Vitro* Anti-Inflammatory Activity

1mL of 5% serum albumin, 1mL of sample (0.125-0.5mg/mL) and 20µg/mL of 1N HCl were mixed. It was incubated at 37 °C for 20 min and then placed in a water bath at 57°C for 3 min. After cooling, 2.5mL of a phosphate buffer solution (0.1M, pH=6.4) was added. The absorbance was measured at 660 nm (Chakravarthi *et al.*, 2017). Aspirin® was used as a reference drug. The percentage protection from denaturation (% of PD) is calculated by using the formula:

$$\% \text{ of PD}=[1-(DO_{Sample}/DO_{Control})]\times 100$$

Where control is the solution having all reagents except the test sample.

2.6. Glucose Uptake by Yeast Cells

The method of Saleem *et al.* (2018), was used for the determination of the activity of the extract in promoting glucose uptake by the yeast cells (*Saccharomyces cerevisiae*). Metformine® was used as a reference product. Briefly, 1mL of the sample was incubated with 1mL of 10mM glucose solution for 10 min at 37°C. Then 100µL of 10% baker's yeast suspension was added.

The mixture was mixed by Vortex for 1min and then incubated for 1h at 37°C. Then the mixture was placed in a centrifuge (3000 rpm, 12 min). Glucose was the supernatant by measuring the absorbance at 620 nm. Determination of the percentage increase of glucose uptake by the yeast cells (% of IGU) was calculated using the following formula:

$$\% \text{ of IGU} = [(DO_{Control} - DO_{Sample})/DO_{Control}] \times 100$$

The control is having all reagents except the test sample.

2.7. Bactericidal Activity

The sensitivity of the six types of pathogenic bacteria (*Bacillus subtilis*, *Listeria innocua*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Salmonella typhimurium, and Staphylococcus aureus*) was tested using the disc diffusion method (Muthukrishnan *et al.*, 2018). The Petri dishes were incubated at 37°C for 24 h. Antibacterial activities were evaluated by measuring the diameters of the inhibition zone (mean ± SD mm), through which the results explain that the bacteria are sensitive, moderately sensitive, or resistant to the antibiotics being tested.

2.8. Statistical Analysis

All assays were made in triplicates and results were expressed as mean ± standard deviation. This study used SPSS for Windows (version 15.0) with paired independent-sample T-test to determine the difference between the effect of the extract and the positive control (p=0.05).

3. RESULTS and DISCUSSION

3.1. Total Phenolic Content, Total Flavonoid Content, Hydrolyzable Tannins, Condensed Tannins, and Anthocyanin Content

Through quantitative analysis (Table 1), it is clear that the MeOH extract of *B. muricata* is rich in phenolic and flavonoid content with 50.05±0.12µg GAE/mg and 30.64±0.8µg QE/mg respectively. It also contains a small content of hydrolyzable tannins, condensed tannins, and anthocyanin with 10.64±0.18µg GA/mg, 2.43±0.12µg CE/mg and 2.36±0.43 µg C-3-GE/mg respectively. These results are consistent with results of Djahra and colleagues (2018) (42.67µg GAE/mg), who estimated the phenolic content of the aqueous extract of the same plant grown in the same region. But it does not agree with the results of Mohammedi *et al.* (2019) study, where the phenolic and flavonoid content of the methanolic extract of the same plant was higher than in MeOH extract (125.27±4.21mg GAE/g and 68.65±1.57mg QE/g respectively). In another work by Bouaziz *et al.* (2009), the quantitative content of phenols and flavanoids of the methanolic extract of the aerial part of this plant grown in Tunisia were; 463±56mg PyE/100g, 18±2mg RuE/100g respectively, which is low compared to that of MeOH extract. The difference between studies may be due to a difference; stage of maturity, geographical location, climatic conditions or stresses applied to the plant, or because of the extraction method and solvent used and its dilution ratios (Pinto *et al.*, 2022).

Table 1. Values of total polyphenol, flavonoid, hydrolyzable tannins, condensed tannins, anthocyanin content, and total antioxidant capacity of MeOH extract of *B. muricata*.

TPC (µg GAE/mg ED)	TFC (µg QE/mg ED)	HTC (µg GAE/mg ED)	TCT (µg CE/mg)	AC (µg C-3-GE/mg)	TAC (µg GAE/mg ED)
50.05±0.12	30.64±0.8	10.46±0.18	2.43±0.12	2.36±0.43	109.1±0.77

3.2. RP-HPLC-UV Analysis

The phytochemical of MeOH extracts of *B. muricata* have been detected by using chromatograms of the RP-HPLC-UV method, with the help of the base peaks of the

chromatogram, as shown in Figure 1. The estimation of the identified compounds were shown in Table 2. Through them, the extract is a component of 70 compounds. 6 compound of 9 reference compounds were identified: phenolic aldehyde; vanillin in a quantity of 0.17µg/mg ED and a flavonoid compound of the flavonol class; rutin in an amount of 0.32µg/mg ED and four phenolic acids is a compound of the class of derivatives of hydroxybenzoic acid; gallic acid with a value of 0.51µg/mg ED, three compounds of the class of hydroxycinnamic acid derivatives; chlorogenic acid (2.88µg/mg ED), caffeic acid (0.47µg/mg ED), and *p*-coumarin (1.33µg/mg ED). The vanillic acid, naringin and quercetin compound were not found by this analysis.

The main compound among the compounds identified was chlorogenic acid. It is known that wild plants grown in the sand such as *B. muricata* are rich in chlorogenic acid (Stanković *et al.*, 2019), followed by *p*-coumarin acid, gallic acid, and then the rest of the compounds in lower concentrations. This work is the first study that investigates the variability of phenolic compounds in MeOH extract of aerial parts of *B. muricata*.

Figure 1. RP-HPLC-UV chromatogram of MeOH extract.

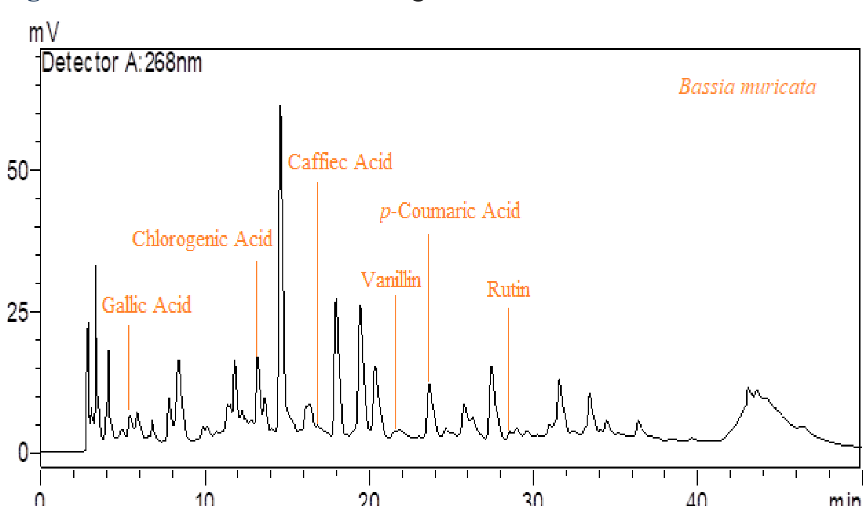


Table 2. Retention time, and regression analysis of reference compounds determined by RP-HPLC-UV analysis in 268 nm wavelength, and content of individual compounds phenolic in plant extract (*B. muricata*).

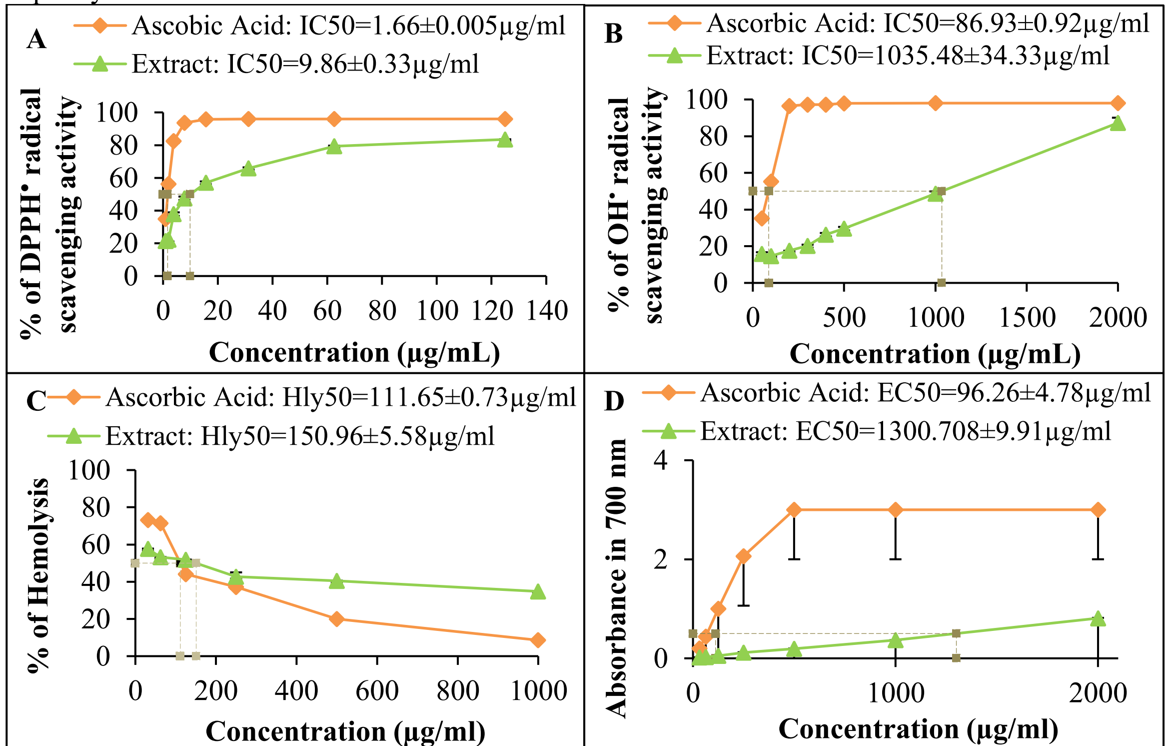
Compounds phenolic			Ret. time (min)	Equation	Content (µg/mg ED)
Phenolic acid	Hydroxycinnamic acid derivatives	Chlorogenic acid	13.392	y=21665x	2.88
		Caffiec acid	16.277	y=84066x	0.47
		p-Coumaric acid	23.817	y=49495x	1.33
	Hydroxybenzoic acid derivatives	Gallic acid	5.29	y=54681x	0.51
		Vanillic acid	15.53	y=65077x	*ND*
	Flavanone	Naringin	34.788	y=19379x	*ND*
Flavonoide	Flavonol	Rutin	28.37	y=28144x	0.32
		Quercetin	45.047	y=45378x	*ND*
		Vanillin	21.46	y=58930x	0.17

y: HPLC peak area. x: concentration (µg/mL). ED: of dry extract. *ND*: not detected

3.3. *In vitro* Antioxidant Activity

Figure 2 shows that the increase in the antioxidant activity depends on the increase in the concentration. The radical scavenging potential was extremely high in MeOH extract of *B. muricata* according to the DPPH• assay (IC_{50}=9.86±0.33µg/mL), while it showed moderate antioxidant activity, when scavenging OH• radicals (IC_{50}=1035.48±34.33µg/mL). These results of the study are consistent with previous studies. Al-barri *et al.* (2021), concluded that the antioxidant activity of 4mg/mL of the methanolic extract of *B. muricata* was 91.3%, using the DPPH• assay. (Chemsa *et al.*, 2016) also found that the extracts: methanol, hexane, ethyl acetate, and water extracts from *B. muricata* had a high DPPH• radical inhibition activity. As for the scavenging activity of *B. muricata* extract against OH•, it was tested for the first time in this study. However, it was demonstrated by Lachkar *et al.* (2021), showed that the methanolic extract of *Haloxylon scobarium* (from the same family *Chenopodiaceae*) had a high OH• radical inhibition activity (20.91±0.27%).

Figure 2. Antioxidant activity of MeOH extract of *B. muricata*: **A:** DPPH• radical scavenging, **B:** OH• radical scavenging, **C:** Effect of plants extracts on hemolysis of erythrocytes, **D:** Ferrous reducing capacity.



Through the graph "C" (Figure 2), the extract showed very effective in protecting erythrocytes from hemolysis by oxidizing agents (temperature and H_2O_2 radical). At a concentration of 150µg/mg was able to protect 50% of erythrocytes, this value was close to the activity of ascorbic acid (IC_{50}=111.65±0.73µg/mL), which is one of the compounds approved for protection against oxidative damage (Kocabaş *et al.*, 2022). To our knowledge, there are no other reports of *B. muricata* as an anti-hemolysis. By this result; we conclude that the extract may contain potent antioxidant compounds, of a lipophilic nature. Such as α-tocopherol or other compounds are biologically capable of inhibiting lipid peroxidation (Ichsan *et al.*, 2022), which is followed by penetration of membrane permeability and thus membrane dissolution. In addition to the flavonoids and phenolic acids whose presence in the extract was confirmed by quantitative estimations and RP-HPLC-UV analysis (Table 1 and Table 2). For example, rutin is one of the most important flavonoids that have an inhibitory effect on hemolysis (Asgary *et*

al., 2005). Tang and Liu (2008) also demonstrated that chlorogenic acid has the ability to stabilize erythrocyte membrane from hemolysis caused by 2,2′-azobis (2-medinopropane hydrochloride) by highly efficient chemical kinetics.

The first main objective of both assays; ferrous reduction capacity assay and phosphomolybdenum power assay. It is a tested of the ability of the antioxidant compounds present in the extract to reduce an oxidant, and here they are Fe^{3+} and Mo (VI) considering that they are substances capable of directly causing oxidative damage to biological groups (fats, proteins, or nucleic acids), to non-toxic or low-toxic compounds and it is Fe^{2+} in the reducing power test and Mo (V) in the total antioxidant capacity test (Prior & Cao, 1999). From the curve "D" in Figure 2, it is clear that the antioxidants of the extract were able to effectively convert Fe^{3+} to Fe^{2+} at a concentration of 1300.708±9.91µg/mL. From Table 1, it is clear that the extract has activity in reducing molybdate with a value of 109.1±0.77µg/mg equivalent to that of gallic acid.

3.4. Sun Protection Factor

The value of the SPF is an indicator that must be mentioned in the sunscreen products, through which it determines its effectiveness in protecting against skin burns and damage due to the sun's rays. Its efficacy is based on its ability to absorb, reflect or scatter the sun's rays. According to the value, it can be divided into categories; minimal (SPF<12), moderate (SPF=126-30), and high sun protection products (SPF≥30). Plants have potential sunscreen activity. This is because it contains antioxidants (Napagoda *et al.*, 2016).

The results of this study showed that the extract had a medium efficacy as a sunscreen with an SPF value of more than 18 (Table 3), while the commercial sunscreen (Avene®) had a very high efficacy of more than 40. From this, *B. muricata* may enter into herbal cosmetics. This effectiveness is probably due to its content of phenolic compounds (Table 1 and Table 2). Macheix *et al.* (2005) mentioned that almost all flavonoids, especially flavones and flavanols, have a high absorption capacity of UVB ultraviolet rays. For instance, applying *p*-coumaric acid to the skin, before or after sun exposure, will be beneficial in terms of relieving UV-induced fever and maintaining skin tone (Boo, 2019).

Table 3. Measured SPF values of the plant extract and commercial sunscreens (Avene®).

	Extract	Avene® (Control)
SPF	18.89±0.005	41±4

3.5. *In vitro* Anti-Inflammatory Activity

Figure 3 "A" shows the effect of the extract on the protection against the occurrence of inflammation, that is, inhibition of protein denaturation. From the results, it is clear that the extract has an anti-inflammatory property similar to the effect of Aspirin®. Where the percentage of inhibition of protein denaturation increased with increasing concentration until it exceeded 60% at a concentration of 0.5mg/mL. These findings support previous conclusions, that this plant possesses different degrees of anti-inflammatory (Chemsa *et al.*, 2016). This property may be due to the phenolic compounds contained in the extract, such as *p*-coumaric acid and gallic acid, which are natural products with known anti-inflammatory properties (Nile *et al.*, 2016). Since the extract is crude, it is not limited to phenolic compounds only. It contains other compounds such as alkaloids and saponins that would have anti-inflammatory properties (Surendran *et al.*, 2021).

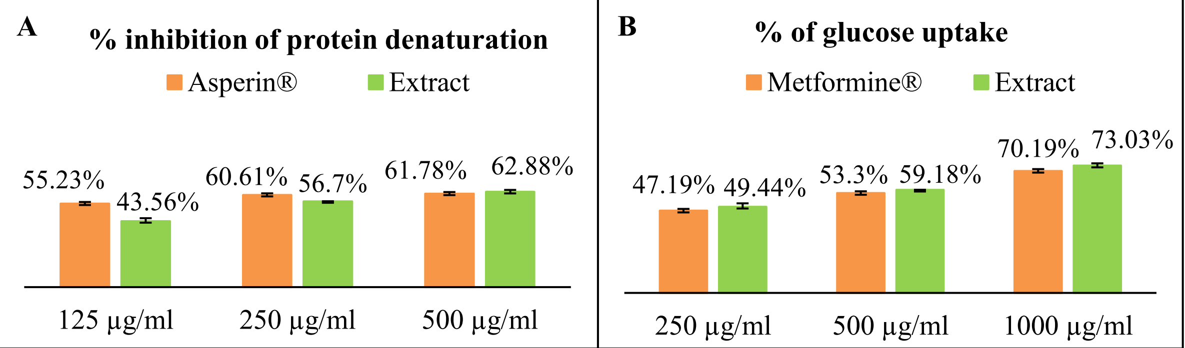
3.6. Glucose Uptake

Through the results obtained in Figure 3 "B", and the statistical analysis where it was $p>0.05$, it is clear that the extract has an effect similar to that of the pharmaceutical drug (Metformine®).

We also note that the higher the concentration, the high the percentage of increase of glucose uptake by the yeast cells, which amounted to 73.03% at a concentration of 0.5g/mL. These results support the ethnopharmacological use of the *B. muricata* as an anti-diabetic plant (Boufous *et al.*, 2017). It is not hidden from us that there are many plants belonging to the *Chenopodiaceae* family that have an anti-diabetic property, mentioned in the use of traditional medicine and confirmed by scientific research as *Haloxylon scoparium*, *Atriplex halimus*, and *Anabasis articulata* (Chikhi *et al.*, 2014; Kambouche *et al.*, 2009; Lachkar *et al.*, 2021).

The activity of the plant extract in enabling glucose uptake by cells in order to reduce blood sugar levels can be attributed to the presence of the phenolic compounds. Where Ayua *et al.* (2021) mentioned that the nutritional phenolic content increases the cells' uptake of glucose by the various tissues of the body. On the other hand, some phenolic compounds have an anticancer effect, which is based on reducing cellular glucose uptake. Through its inhibitory effect on the expression of SGLT1 and GLUT2. Cancer tissues are also likely to suffer more severely than normal tissues from glucose deprivation due to their heavy dependence on large amounts of glucose (Keating & Martel, 2018).

Figure 3. Effect of MeOH extract of *B. muricata* on: **A**: Protein denaturation. **B**: Percentage of increase in the glucose uptake by the yeast cells.



3.7. Antibacterial Activity

The data showed in the Table 4 that *B. muricata* extract had weak antibacterial properties against the study organisms; both Gram-positive and Gram-negative bacteria, compared to approved antibiotics (Azithromycine®, Gentamicine®). While the negative control (DMSO) had no effect on the bacteria growth. The diameters of inhibition induced by the extract ranged from 0-11.5±1.3mm by different doses (4, 2, 1, 0.5mg). The extract was able to inhibit the growth of five strains of bacteria (*B. subtilis*, *L. innocua*, *S. aureus*, *E. coli* and *P. aeruginosa*), with limited sensitivity (8.2±0.3 to 11.5±1.3mm). It can be noted from Table 4 that *E. coli* was the most susceptible of the five organisms and *P. aeruginosa* the least. These results agreed with Chemsa *et al.* (2016) as the ethanol extract had limited sensitivity against *P. aeruginosa* 8mm and *E. coli* 9.5mm. But it did not correspond to the results Al-barri *et al.* (2021), which expressed that the methanol extract of *B. muricata* has a medium sensitivity to *E. coli* 16±0.33mm and *P. aeruginosa* 14±0.57mm, and very high efficacy against *B. subtilis* 20±2.02mm. Regarding the lack of efficiency of *B. muricata* extract against *S. typhimurium*, there is currently no scientific study to which it can be compared.

This antibacterial performance of the extract of *B. muricata* can be attributed to the use of the crude extract. Where it is assumed that the crude extract in general contains flavonoids in glycosidic form, and it is mentioned that the sugar present in them reduces the effectiveness against some bacteria (Negi, 2012).

Table 4. Antibacterial activity of MeOH extract of *B. muricata*, DMSO, and antibiotics; against the six bacterial strains, by measuring the diameter of the inhibition zone (mm) using the disc diffusion method.

Tre	Inhibition zone diameter (mm)					
	Gram-positive			Gram-negative		
	B. subtilis	*L. innocua*	*S. aureus*	*E. coli*	*P. aeruginosa*	*S. typhimurium*
	ATCC-6633	CLIP-74915	ATCC-6538	ATCC-25922	ATCC-9027	ATCC-14028
4 mg	10±1.7	9.7±0.6	9±1.7	11.5±1.3	8.2±0.3	*NI*
2 mg	10±7	9.7±0.6	10.7±2.1	9.2±0.3	8.1±0.7	*NI*
1 mg	7.3±1.5	10±0	12±1.7	10.3±1.2	8±0	*NI*
0.5 mg	*NI*	9.3±0.6	10.7±0.6	9.5±0.5	8±0	*NI*
DMSO	*NI*	*NI*	*NI*	*NI*	*NI*	*NI*
Azi	28	19	23	/	/	/
Gen	/	/	/	16	15	14

Tre: Treatments, Azi: Azithromycine®, Gen: Gentamicine®, *NI*: Not inhibited, /: Not tested

4. CONCLUSION

This report is considered the first of its kind because it presents the first quantitative and qualitative analysis of phenolic content using HPLC analysis, and provides an assessment of the wide range of biological activities (*in vitro*) of *Bassia muricata* (L.) growing in the northern Algerian desert.

In conclusion, MeOH extract of the *Bassia muricata* has antioxidative, anti-inflammatory and antibacterial activity. It can also be a protection factor from the sun's rays and a factor that enhances the uptake of glucose by cells. This suggests that constituents of this plant could be useful as a source of bioactive compounds for food, in the pharmaceutical industry, and/or manufacture of cosmetics. However, further investigations are necessary to include the *in vivo* biological activities of the studied plant. It confirms the effectiveness and determines the toxicity and side effects when applying the treatment. It is also advisable to re-prepare the extract using different extraction methods and other solvents of different polarity, or using nanophytomedicine techniques.

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Declaration of Conflicting Interests and Ethics

The authors declare no conflict of interest. This research study complies with research and publishing ethics. The scientific and legal responsibility for manuscripts published in IJSM belongs to the authors.

Authorship Contribution Statement

Noura Gheraissa: Conception, Design, Fundings, Data Collection and Processing, Analysis and Interpretation, Literature Review and Writing. **Ahmed Elkhalifa Chemsa:** Conception, Design, Supervision, Fundings, Materials, Analysis and Interpretation, Writing, and Critical Review. **Eman Ramadan Elsharkawy:** Conception, Supervision, and Writing. **Nezar Cherrada:** Design, Literature, Data Collection and Processing, Review and Writing

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