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Evaluation of Antibacterial Properties of Some Wild Medicinal Plants in Madinah Province, Saudi Arabia

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Interest in the antibacterial activity of natural items against multidrug-resistant bacteria has been increased during the past few decades because of worldwide bacterial resistance. Antibacterial activity of the ethanolic extracts of five wild medicinal plants (*Spergularia diandra, Solenostemma argel, Pulicaria incisa, Lacctuca serriolla* and *Traganum nudatum*) was estimated against four human pathogenic bacteria. Five wild medicinal plants were determined by the agar diffusion method against some human pathogenic bacteria. Findings showed that only *Bacillus cereus* was susceptible to four of the five ethanolic extracts of *S. diandra, P. incisa, L. serriolla,* and *T. nudatum* among the four harmful bacteria. In contrast, none of the examined bacteria were affected by the ethanolic extract of *S. argel*. In this work, the antibacterial activity of five ethanolic wild plant extracts against four bacterial pathogens was assessed at various doses. The information supports a variety of medical and pharmaceutical applications for the plants under study, notably for infectious microorganisms.

Keywords: Antibacterial activity; antibiotic resistance; Wild plants

INTRODUCTION

The importance of wild plant species to the development of human well-being and means of subsistence has long been acknowledged. They provide a wide range of social, economic, and environmental advantages (Alsharif and Waznah, 2020; El-Seedi et al., 2022). Wild plants produce items like food, medicine, fuel, and cork, which have direct economic worth. They also contribute to non-marketed functions like soil preservation, water control, and recreational activities, which have indirect value (Sánchez-Mata et al., 2012). The World Health Organization (WHO) estimates that traditional medicine serves the fundamental medical needs of over 80% among world's population. Some of the substances that known to give plants their medicinal significance includes alkaloids, flavonoids, tannins, and phenolic compounds, which are naturally occurring in plants and have physiological effects on people (Al-Mussawi, 2014).

In tropical and subtropical nations, microbial diseases brought on by bacteria, fungi, and viruses are a significant worldwide health concern. Multiple drug resistance in human pathogenic bacteria has been brought on by the careless use of commercial antimicrobial medicines (Gutmann et al., 1988). Bacterial infections are one of the leading causes of illnesses and mortality worldwide (Moore et al., 2017). Modern medicine relies heavily on antibiotic therapy to address microbiological illnesses. Drug-resistant infections arise because of antibiotic misuse, abuse, and overuse. Furthermore, the emergence, propagation, and persistence of multidrug-resistant (MDR) bacteria, also known as "superbugs," represent a serious threat to both human and animal health as a result of antibiotic resistance (Laxminarayan et al., 2013; Aslam et al., 2018).

A species of herbaceous plant called *Lactuca serriola* L. (Compositae) is also known as prickly lettuce, jagged lettuce, Kahu, and locally in Madinah as Khas shaik (Srivastava et al., 1996). The plant's original home is in places like the Himalayas, Siberia, and the Atlantic Ocean. Traditional medicine has employed *L. serriola* L. for a number of therapeutic uses, including the treatment of bronchitis, asthma, and as a sedative, hypnotic, expectorant, and cough suppressant. To treat gastrointestinal and other conditions, it is also employed as a purgative, demulcent, diuretic, antibacterial, vasorelaxant, and antispasmodic (Uniyal et al., 2006).

A desert shrub called *Pulicaria incisa* (Lam.) is well-known for its fragrant perfume. It goes by the names "Aatitisa" in Morocco and Sakab or Esnah in Saudi Arabia. In northern Egypt, the herb's decoction is frequently used as a sugar-sweetened alternative to tea (Nabiel, 2003; Amer et al., 2007). It has also historically been used in traditional medicine as a hypoglycemic agent and to treat heart conditions. Large concentrations of unsaturated fatty acids are reported to be present in *P. incisa* (Mansour et al., 1990; Shabana et al., 1990; Nabiel, 2003; Saleh, 2003; Abd El-Gleel and Hassanien, 2012), which can lower levels of total lipids, total cholesterol, and triglycerides. As a result, it has been suggested as a potential agent to decrease cholesterol (Mansour et al., 1990).

The Asclepiadaceae plant *Solenostemma argel* is also referred to as Hargal in local dialects. This plant's leaves have long been used to cure a number of illnesses, including diabetes mellitus and kidney inflammation. For instance, patients experienced a purgative response from the leaf extract. The leaves have also been used as an antipyretic to treat inflammation, coughs, and colds. Additionally, the leaf powder had been used externally to treat inflammatory lesions. High concentrations of saponin, flavonoid, and glycoside, which have been reported to have antibacterial activities, may be discovered in *S. argel*'s leaves (Hamadnalla and El-Jack, 2019).

The plant *Spergularia diandra*, often known as Sneslah or Reqeqa, is a member of the Caryophyllaceae family. *S. diandra* is one of many species in this family that contain saponins, which are known to produce foam when combined with water (Stevanovic et al., 2019). Numerous phytochemicals, including amino acids, vitamins, minerals, flavonoids, glycosides, alkaloids, and tannins, have been found in the *Spergularia* genus (Lee and Jung, 2012; Gamal El-Dien et al., 2014; Cho et al., 2016; Lateff et al., 2021), which includes *S. diandra*, according to studies. *S. diandra* has been investigated for its range of biological properties, including its anti-inflammatory, anti-adipogenic, pro-osteoclastogenic, antioxidant, and hypoglycaemic actions, as well as its capacity to lessen insulin resistance (Gamal El-Dien et al., 2014; Karadeniz et al., 2014; Kim et al., 2014a, 2014b; Cho et al., 2016; Miri et al., 2016).

The Chenopodiaceae family includes *Traganum nudatum* Delile, also referred to as Damran. This plant is widely used in traditional medicine in the Algerian Sahara to cure a range of ailments, including diabetes, rheumatism, diarrhea, otitis, and skin issues. The leaves can also be used to make a decoction that is a natural treatment for low back pain (Telli et al., 2016). The current study used various ethanolic extract concentrations against certain pathogenic bacteria to examine the antibacterial activity of five wild medicinal plants.

MATERIALS AND METHODS

2.1 Plant samples and extraction

Five plants were gathered from various locations throughout Madinah, representing five different species: *S. diandra, S. argel, P. incisa, L. serriolla*, and *T. nudatum*. The plants were identified by the biology department of Taibah University's faculty of science. Plant aerial parts were air dried at ambient temperature for 4-5 days. Then, all plants were grounded. They were then extracted for 48 hours using a combination of 70% ethanol and 30% water (70/30 V/V). A lower vacuum pressure was used to filter and concentrate each extraction at a temperature below 50 °C. Until the analysis, the final extract was stored at 4 °C.

2.2 Bacterial strains

Bacterial strains were provided by King Fahad Hospital in Al Madinah City. There were three Gram-positive (*Staphylococcus aureus, Bacillus cereus,* and *Streptococcus pneumoniae*) and one Gram-negative (*Escherichia coli*) bacteria.

2.3 Antibacterial activity

A slightly modified agar disc diffusion procedure was used with three concentrations (100, 50, and 25 mg/ml) to test the antibacterial activity of the gathered plant against the chosen clinical pathogens at various concentrations (Huang et al., 2011; Rehab and Hossain, 2016). Positive controls included the antibiotics rifampicin (RD5), erythromycin (E15), and ampicillin (Amp10). 10 ml of the test tube received 10 mg of the extract. Each extract received 10 ml of dimethyl sulfoxide (DMSO), and various produced compounds are labelled according to their quantities. Using the serial dilution procedure, several concentrations, including 100, 50, and 25 mg/ml, were prepared. On Müller Hinton agar petri dishes, several bacterial isolates were evenly distributed using a cotton bird. Next, filter paper (discs measuring 6 mm in diameter)

2.4 Statistical analysis

Data were represented as the mean ± SD using Graph Pad Prism software (version 5) and ANOVA followed by Tukey’s post hoc test where $p<0.05$ was considered significant.

RESULTS

3.1 Effect of the different concentrations of five wild plant extracts

Table 1 displays the antibacterial activity of five wild medicinal plant extracts against three Gram-positive and one Gram-negative bacteria at various doses (25, 50, and 100 mg/ml).

Table 1 Effect of antibacterial activity of five wild plant extracts against four pathogenic bacteria (inhibition zones represented in centimetres).

Tested Bacteria	**Diameter of inhibition zones in cm with different concentrations (Mean ± SD)**															**Commercial Antibiotics (positive controls)**		
	L. serriolla			***P. incisa***			***S. argel***			***S. diandra***			***T. nudatum***			**(Amp10)**	**(E15)**	**(RD5)**
	25	**50**	**100**	**25**	**50**	**100**	**25**	**50**	**100**	**25**	**50**	**100**	**25**	**50**	**100**			
E. coli	1.6± 0.04	1.75 ± 0.04	0.00 ± 0.0	0.00 ± 0.0	0.00 ± 0.0	0.00 ± 0.0	0.00 ± 0.0	0.00 ± 0.0	0.00 ± 0.0	0.00 ± 0.0	0.00 ± 0.0	0.00 ± 0.0	0.00 ± 0.0	0.00 ± 0.0	1.68 ± 0.06	2.71 ± 0.02	2.51 ± 0.02	2.78 ± 0.02
S. pneumonia	0.00 ± 0.0	0.00 ± 0.0	0.00 ± 0.0	0.00 ± 0.0	0.00 ± 0.0	0.00 ± 0.0	0.00 ± 0.0	0.00 ± 0.0	0.00 ± 0.0	2.2 ± 0.04	2.35 ± 0.04	2.5 ± 0.04	0.00 ± 0.0	0.00 ± 0.0	0.00 ± 0.0	2.81 ± 0.02	2.48 ± 0.02	2.73 ± 0.02
S. aureus	0.00 ± 0.0	0.00 ± 0.0	0.00 ± 0.0	0.00 ± 0.0	0.00 ± 0.0	2.03 ± 0.04	0.00 ± 0.0	0.00 ± 0.0	0.00 ± 0.0	0.00 ± 0.0	0.00 ± 0.0	0.00 ± 0.0	0.00 ± 0.0	0.00 ± 0.0	1.96 ± 0.04	2.75 ± 0.04	2.51 ± 0.02	2.71 ± 0.02
B. cereus	2.93 ± 0.02	3.06 ± 0.04	3.18 ± 0.02	2.98 ± 0.02	2.98 ± 0.02	3.11 ±0.02	0.00 ± 0.0	0.00 ± 0.0	0.00 ± 0.0	2.85 ± 0.04	2.96 ± 0.02	3.06 ± 0.04	2.95 ± 0.04	3.16 ± 0.04	3.26 ± 0.02	2.8 ± 0.04	2.46 ± 0.02	2.81 ± 0.02

(Amp10): ampicillin; (E15): erythromycin; (RD5): rifampicin;(**0.0):** bacteria were not affected by the plant extract.

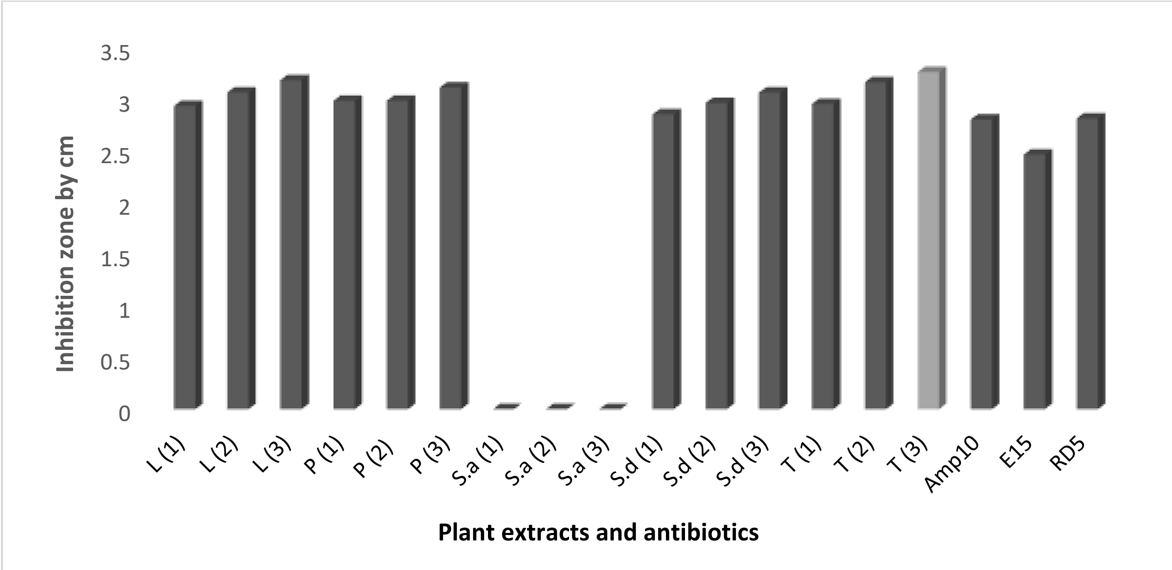

Figure 1 The differences in antibacterial activity between the tested plant extracts and antibiotics against *B. cereus.* (L): *L. serriolla*, (P): *P. incisa*, (S.a): *S. argel*, (S.d): *S. diandra*, (T): *T. nudatum*, (Amp10): ampicillin, (E15): erythromycin, (RD5): rifampicin, concentrations: (1) stands for 25%, (2): 50% and (3): 100%.

The table demonstrated that, at a concentration of 100 mg/ml, the ethanolic extract of *T. nudatum* exhibited the maximum activity against *B. cereus* and the lowest activity against *E. coli*. On the other hand, the ethanolic extract from *S. argel* in various doses exhibited no action against the tested microorganisms.

Furthermore, the ethanolic extracts of the three plants (*S. diandra, P. incisa* and *L. serriolla)* were convergent at concentrations of 25, 50 and 100 mg/ml against *B. cereus,* which was the most sensitive bacterium among all other tested bacteria. It showed the highest inhibition effects with the ethanolic extracts of *S. diandra, P. incisa, L. serriolla* and *T. nudatum*, except *S. argel*. In contrast, *S. pneumonia* was the most resistant bacteria challenged with different concentrations of ethanolic extracts from *S. argel, P. incisa, L. serriolla* and *T. nudatum*. Moreover, the ethanolic extracts of the four collected wild plants showed the best effect against *B. cereus* compared to the effects of the three antibiotics ampicillin, erythromycin and rifampicin which illustrated in Figure 1.

DISCUSSION

Due to the existence of several compounds with different levels of abundance, it might be challenging to pinpoint the precise bioactive substances that are responsible for the therapeutic benefits of plant extracts (Enke and Nagels, 2011). The combined action of numerous distinct chemicals, which may have synergistic, additive, or antagonistic effects, is frequently what gives these extracts their overall efficacy (Stermitz et al., 2000; Stermitz et al., 2002; Wagner and Ulrich-Merzenich, 2009; Ulrich-Merzenich, 2010; Junio et al., 2011). In some circumstances, using therapeutic plant extracts may result in a more potent reaction than taking the same amount of a single isolated component (Abreu et al., 2012). Antimicrobial resistance makes the study of compound synergy in plant extracts particularly pertinent since it can shed light on the diversity, flexibility, and complexity of the compounds. Research on synergy can help us better understand the medicinal benefits of complex plant mixes (Vaou et al., 2022).

The results showed that the ethanolic extract of *T. nudatum*, with a zone of inhibition of 3.2 cm, had high action against the Gram-positive bacterium B. cereus at a dosage of 100 mg/ml. The antibacterial effects of *T. nudatum* water extracts have been discovered in several prior investigations; this is likely because the plant's water extracts contain phytochemicals like polyphenolic compounds and tannins. Numerous species are known to be inhibited by polyphenolic substances (Labed et al., 2010). The way that tannins work is based on their capacity to bind proteins, which prevents the creation of new proteins in cells (Stern et al., 1996). Furthermore, it has been discovered that tannins, including naringenin, catechin, and vanillin, can bind proteins and prevent the creation of new proteins in cells (Mouderas et al., 2019).

The study found that *L. serriolla, P. incisa,* and *S. diandra* also had clear activity against *B. cereus,* with zones of inhibition of 3.1 cm, 3.1 cm, and 3.0 cm, respectively. The findings of this study are in agreement with those of other studies that demonstrated *L.*

serriola's antibacterial abilities (Yadava and Jharbade, 2008). From its seeds, these researchers extracted a triterpenoid saponin with antibacterial properties against different bacteria and fungi. Aqueous and methanolic leaf extracts of *L. serriola* also shown strong dose-dependent antipseudomonal action against clinical isolates of multidrug-resistant *Pseudomonas aeruginosa* (Balogun et al., 2017). *P. crispa* was found to be the most effective plant on all bacterial strains, including *S. aureus, B. cereus, S. pneumoniae*, and *E. coli*. *P. incisa* has also been reported to have bioactive components with antioxidant and antibacterial effects in its essential oil (Lougraimzi et al., 2020; Waznah and Alsharif, 2022).

In addition, *S. diandra*'s aerial portion includes useful chemical substances such phenols, saponin, glycoside, flavonoid, and tannin, all of which have been positively identified apart from the alkaloids, which are unique to *S. diandra* (Lateff et al., 2021).

CONCLUSIONS

With the prevalence of bacterial resistance problems, interest in the antibacterial activity of natural products against multi-drug resistant bacteria has been exploded during the past decades. In this study, the effects of five ethanolic wild plant extracts with different concentrations were evaluated against four bacterial pathogens. Data illustrated that plant extracts, especially *L. serriolla, P. incisa, S. diandra,* and *T. nudatum*, could be used as sources of novel antibacterial agents to treat various bacterial diseases, particularly those involving MDR bacterial species.

Supplementary materials

Not applicable

Author contributions

SMA designed the experiments, supervised the study, performed the field work, collected all samples, extracted the plants, prepared powder forms, and edited the manuscript. MSW achieved bacterial sensitivity tests for all samples. DAB wrote the manuscript.

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Informed Consent Statement

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Data Availability Statement

All of the data is included in the article/Supplementary Material.

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Conflict of interest

The authors declared that present study was performed in absence of any conflict of interest.

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