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Original article

The Inhibitory Efficiency of Aqueous Extracts of *Quercus infectoria* against *Escherichia coli, Salmonella, Streptococcus*, and *Staphylococcus*

Muftah Omar Ali

Department of Botany, Faculty of Science, Sirte University, Sirte, Libya
Corresponding Email. *muftah.omar@su.edu.ly*

Abstract
In light of the extensive utilization of popular medicine, herbal remedies, and medicinal plants in the treatment of microbial infections in Libyan society, the present study was conducted to investigate the impact of aqueous extracts of Quercus infectoria on two bacterial groups: Gram-negative (Escherichia coli and Salmonella) and Gram-positive (Streptococcus and Staphylococcus). The estimation of antibacterial activity was carried out by implementing the Disc Diffusion Technique. The present study focuses on the aqueous extracts of Quercus infectoria bark. The aqueous extracts of Q. infectoria demonstrated the greatest effect on the growth of gram-positive microorganisms, Streptococcus and Staphylococcus, with inhibitory zones measuring 1.7 mm and 0.9 mm, respectively. The impact of the extract on Gram-negative isolates (Salmonella, Escherichia coli) was less significant, with respective measurements of 0.6 mm and 0.2 mm.
Keywords: *Quercus infectoria, Inhibitory zone, Gram-Positive, Gram-Negative Isolates, Aqueous Extract.*

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Introduction

A considerable number of active compounds found in various medicinal plants have been utilised to combat microbial infections. Extract has been identified as a potential agent for the inhibition of the growth of certain bacterial species associated with intestinal and skin diseases, as well as pharyngitis. Medicinal and aromatic plants and herbs have been used both as a source of sustenance and as therapeutic agents due to their active ingredients [1]. Consequently, in light of the challenges associated with conventional antibiotic treatments, there has been a global shift towards the utilization of plant compounds (extracts), which offer a range of therapeutic benefits, are readily accessible, and are cost-effective. This development subsequently led to their widespread adoption in the late 1990s, a phenomenon that has been termed "alternative medicine" [2].

In recent years, scientific research has focused on plants to develop natural treatments that strengthen immunity and reduce the risks associated with the overuse of antibiotics and the resulting increase in microbial resistance to these drugs. Numerous scientific studies indicate that plant extracts have, and will continue to have, a significant role in the treatment of diseases and the combat of microbes. In this context, Manhel and Kareem. [2015] confirmed that the increasing resistance of microorganisms to synthetic drugs, such as some types of bacteria, is a worrying fact due to the spread of disease and the emergence of more dangerous resistant bacterial strains in public hospitals. A number of studies have demonstrated that a significant proportion of active substances found in plants have been employed in the fight against microbes, thereby validating their efficacy.

Medicinal plants such as *Quercus* contain a variety of active compounds, including phenols and glycosides, which have anti-inflammatory properties and can combat inflammation caused by the growth of various microorganisms [4]. The substance under scrutiny contains a plethora of active compounds, with tannins comprising 15-20% of the total composition, as previously determined by Bogdadi *et al*. [2007]. This genus comprises numerous species of oak, encompassing both shrubby and large, long-lived tree forms, with some specimens capable of attaining ages ranging from 500 to 2000 years (Carulus Linnaeus). As Burlaco et al. [2020] demonstrated, the alcoholic extract of *Quercus infectoria* has the capacity to inhibit the growth of *Staphylococcus* spp. by reducing the adhesion of bacterial colonies to epithelial cells [7]. *Staphylococcus, E. coli,* and *Salmonella* spp. are significant causative agents of enteric illness. As foodborne pathogens, they constitute a major global health challenge. As demonstrated in the research, hot water and alcohol extracts of *Quercus infectoria* bark are efficacious against certain Gram-positive bacteria species, including Staphylococcus species, and Gram-negative bacteria [8]. The bark has been demonstrated to have therapeutic benefits in the treatment of diarrhoea, swollen membranes, sore throats, and skin inflammation.

It has been demonstrated that extracts of medicinal plants, such as oak, have an inhibitory effect on gram-negative bacteria, which are of importance as pathogens [9]. These bacteria are responsible for causing foodborne infections and antimicrobial resistance; the resulting symptoms may include diarrhea, nausea, and severe infections [10]. The objective

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of this study is to estimate the impact of an aqueous extract of *Quercus infectoria* on gram-negative and positive bacterial isolates.

Methodology

Bacterial isolates

The following table details the bacterial samples that were identified and tested in the microbiology laboratory at the Faculty of Medicine, University of Sirte: (Table 1).

Table 1. Bacterial Genera and their isolation source

Site of isolation	Bacterial Isolates
The presence of the infection was localised to the nasal cavity of an infected person.	*Staphylococcus aureus*
This genus was isolated from the oral environment.	*Streptococcus*
The isolation of *Salmonella* was obtained from the bathroom environment.	*Salmonella*
The isolate was derived from a specimen obtained from a bathroom environment.	*Escherichia coli*

Preparation of aqueous plant extracts and culture medium

The plant material selected for the study was collected, washed with distilled water, and then dried by spreading it out on paper and leaving it in a shaded area for between eight and ten days. Subsequently, the plant was subjected to grinding using an electric grinder. The plant extract was prepared using the infusion method as outlined in [11]. Four grams of the plant powder were added to 250 ml of distilled water, after which the mixture was left to steep for 24 hours in a shaker. The liquid that was filtered was collected, transferred into clean bottles, and stored in the refrigerator for subsequent use [12]. The differentiation of bacterial isolates was achieved through the application of Gram staining, a technique that relies on the distinct variation in the structure and chemical composition of the cell wall [13].

The culture medium was prepared by accurately measuring 10 g of Mueller-Hinton II Agar medium and thoroughly dissolving it in 250 ml of distilled water. The sterilisation of the medium was achieved by subjecting it to autoclaving for a duration of 15 minutes at a temperature of 121°C (1 atmosphere pressure). The bacterial species were cultivated on the nutrient medium at a temperature of 37°C for 24 hours.

The effect of the plant extract was measured using the disc diffusion technique to assess the performance of the sensitivity test [14]. The suspension of bacterial growth was prepared from a culture that had been cultivated for a period of 24 hours. These colonies were transferred into a test tube containing 2 ml of distilled water, and the mixture was thoroughly agitated using a vortex mixer. Subsequently, bacterial species were cultivated on the surface of the medium using a sterile cotton swab. Filter paper discs (5 mm in diameter) were immersed in the plant extract for a period of one hour until they had been saturated. Subsequently, three discs of each extract were meticulously placed into each plate using sterile forceps. The present study utilised ciprofloxacin as a control antibiotic. The cultures were then subjected to an incubation process at a temperature of 37°C for a period of 24 hours.

Results and Discussion

The findings of this study demonstrated that the effect of aqueous extract of *Quercus infectoria* was obvious on the growth of *Streptococcus* and *Staphylococcus* aureus, with a diameter of 1.7 mm and 0.9 mm, respectively. However, its impact against *Salmonella* and *E. coli* was less significant, with measurements ranging from 0.6 mm to 0.2 mm. This outcome is attributable to the properties of the outer membrane of Gram-negative bacteria, which contains an endotoxin layer of lipopolysaccharide (LPS) (see Table 2 and Figure 1).

Table 2. The mean diameters of the Inhibitory zone of the tested bacteria (in millimeters)

average diameters of inhibition zones (in mm) for the tested bacteria		
Bacterial isolates	**Ciprofloxacin**	***Quercus infectoria***
Staphylococcus aureus	1.8	0.9
Streptococcus	1.8	1.7
Salmonella	1.8	0.6
E. coli	1.8	0.2

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The passage of the extract through the cell wall of Gram-positive bacteria is facilitated in comparison to Gram-negative bacteria [15]. Basri and Fan [2005] illustrated that the most susceptible bacterium to aqueous and alcoholic extracts of *Quercus infectoria* was identified as *Staphylococcus aureus*. However, a weak inhibitory effect against *Bacillus subtilis* and *Pseudomonas aeruginosa,* while *E. coli* remained unaffected. It has been proven that *Q. infectoria* contains elevated levels of tannins, which have been hypothesised to be responsible for the inhibition of bacterial isolates [16-17]. Tannin is known to be soluble in both water and alcohol, and it has been observed to precipitate with protein [18].

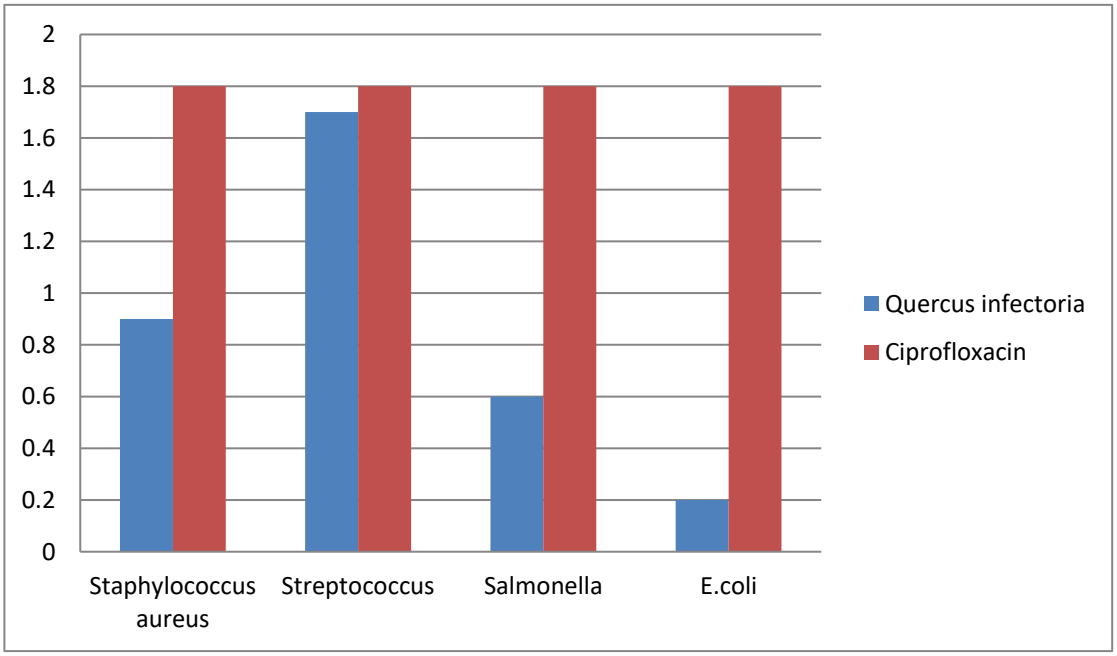

Figure 1. The efficacy of the water extract of Quercus infectoria against bacterial isolates

Conclusion

The results of aqueous extracts clarify a significant effect on isolates of Streptococcus and Staphylococcus. The most extensive inhibitory zone was observed in *Streptococcus*, measuring 1.7 mm, while the least extensive inhibitory zone was observed in *E. coli*, measuring 0.3 mm. In the ensuing studies, it is imperative to assess the impact of varying concentrations of each extract on the proliferation of the species identified in this investigation and other bacterial species. This should be achieved by using all cohol extracts, such as ethanol, methanol, and acetone.

Conflict of interest. Nil

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