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Antimicrobial activity of *Taraxacum officinale* against *Enterobacter cloacae*

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Abstract
This study was conducted to determine antimicrobial properties of the *Taraxacum officinale* against *Enterobacter cloacae.* 2g samples of *Taraxacum officinale* were extracted with 95% ethanol. The suspension or 95% ethanol was infused into sterile discs. The discs were placed on bacterial plated plates and incubated at 37 degrees Celsius for 24 hours and zones of inhibition were measured. *T. officinale* demonstrated antimicrobial activity against *E. cloacae* with a mean zone of clearing of 24 mm. *Taraxacum* previously demonstrated activity against a wide range of bacteria, however, previous studies have shown that *Taraxacum* lacked antimicrobial activity against *Enterobacter spp*. This study provides evidence that *Taraxacum* displays antimicrobial properties against E. *cloacae,* a pathogen of major antimicrobial resistance concern.

Keywords: Antimicrobial, bacteria, gram-negative, drug resistance, microbiology, nosocomial

1. Introduction
Antibiotics are a critical treatment to cure bacterial infections [1]. However, antibiotic resistance is quickly becoming a troubling global health problem for clinicians and scientists [2-3]. What is most troubling is the fact that bacteria have demonstrated some degree of resistance against all known antibiotics through a wide variety of mechanisms such as mutations and gene transfers [1-3]. Infections with drug resistant bacteria are associated with much higher rates of adverse outcomes [4]. Consequently, antibiotic resistance has cost millions of lives and billions of dollars in healthcare costs [2-5]. The deaths and costs due to antibiotic resistance are expected to dramatically increase into the future as bacteria continue developing resistance [3]. Research for compounds with antimicrobial activity is a desperate need to combat antibiotic resistance [6]. *Taraxacum officinale*, commonly known as the Dandelion or Lion's tooth, is a common plant that is native of Eurasia, but commonly grows throughout many parts of North America [7]. *Taraxacum* has been used as a medicine for hundreds of years with known antioxidant, hepatoprotective, and anticancer properties [8].*Taraxacum officinale* in previous research has shown antimicrobial activity against *S. aureus, methicillin-resistant S. aureus, and B. cereus, E. coli, K. pneumonaie, and P. mirabilis* [9,10]. This activity is believed to stem from secondary metabolites of *Taraxacum officinale,* known as triterpenoids [10].While *Taraxacum officinale* has demonstrated antimicrobial properties, previous studies of *Taraxacum officinale* have failed to demonstrate antimicrobial activity against several species of bacteria, including *Enterobacter spp, P. aeruginosa, and S. enterica* [10]. This study investigates the antimicrobial activity of *Taraxacum officinale* against *Enterobacter cloacae (E. cloacae). Enterobacter cloacae* is a gram-negative rod that has been known to cause large nosocomial infections and outbreaks [11, 12], *E. cloacae* has also been known to cause community acquired urinary tract infections, osteomyelitis, and respiratory infections [11].*Enterobacter* is listed as one of the ESKAPE organisms, which is a list of organisms known for their growing virulence and multidrug resistance [6], *Enterobacter cloacae* is of particular concern due to its antibiotic resistance against Carbapenem one of the strongest available broad-spectrum antibiotics [11-13]. *Enterobacter* has also begun demonstrating resistance to several other last-resort antibiotics such as colistin [6]. *Enterobacter* is very versatile and can rapidly gain resistance through a large number of mechanisms [14]. The need for new compounds with activity against *E. cloacae* is vital for overcoming the drug resistance to the current treatment options.
Although *Taraxacum officinale* has not previously demonstrated antimicrobial activity against other *Enterobacter spp.*, we hypothesize in this study that *Taraxacum officinale* will demonstrate antimicrobial activity against *Enterobacter cloacae* due to its antimicrobial properties against several other gram-negative bacteria.

2. Method

2.1 Sample extraction and disc preparation

2g samples of *Taraxacum officinale* were homogenized and suspended in 95% ethanol [15]. The filtrate from the homogenate ethanol mixture was infused into sterile discs as previously described [15]. The 95% vehicle control was also infused into a blank disc to control for vehicle effect. Glycerol stocks of bacteria were scaled and agar plates prepared as described earlier [15]. A 100 microliter suspension of the scaled bacteria was diluted with 9 ml of 1% saline solution and 100 ul of this dilution was plated [15]. Discs previously infused with extracts or vehicle control (95% ethanol) were placed on bacterial plated plates and incubated at 37 degree Celsius for 24 hours and zones of inhibition were measured.

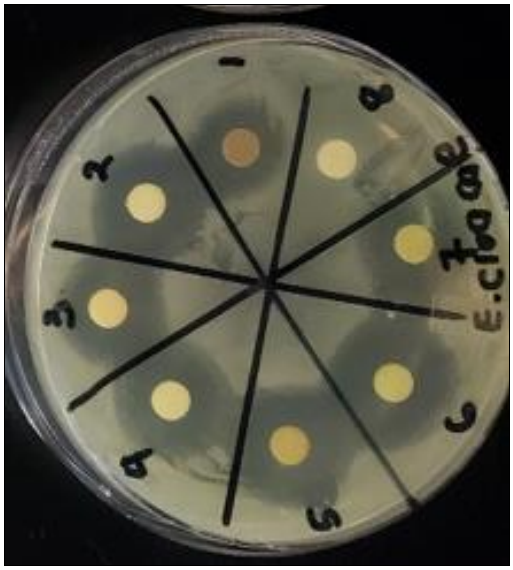

Fig 1: *Taraxacum officinale* (Position 6) and blank disk (Position 8) against *E. cloacae.*

3. Result

Taraxacum officinale demonstrated antimicrobial activity against *E. cloacae* with a mean zone of clearing of 24 mm.

Table 1: *E. cloacae* zone of clearing (in mm) against a blank disk and *Taraxacum officinale*

	***E. cloacae* (zone of clearing in mm)**
Blank Disk	0 mm
Taraxacum officinale	24m

4. Discussion

This study has demonstrated *Taraxacum officinale* has antimicrobial activity against *Enterobacter cloacae* by production of a 24 mm mean zone of clearing. *Enterobacter cloacae* resistance is presenting as a challenge in the prevention of nosocomial infections and outbreaks [11, 12]. Antibiotic resistance is presenting as a large cause of mortality and costs to healthcare systems [2-5]. *Enterobacter* is one such organism that is greatly contributing to this problem due to its resistance against many last-resort antibiotics [6, 11-13]. In previous studies, *Taraxacum officinale* has failed to demonstrate activity against *Enterobacter* [10]. From the results of this study, we have shown that *Taraxacum officinale* does have antimicrobial activity against *Enterobacter cloacae* and this is significant. We also believe the results are significant due to the high antibiotic resistance rates in *Enterobacter*. We believe Taraxacum maintains a promising position in the search for antibiotics and its activity needs to be further explored.

We acknowledge that this study was limited in its ability to test drug resistant strains of *E. cloacae* due to facility biohazard concerns. However, due to the growing resistance, any compound that demonstrates activity against *Enterobacter* should be explored. We believe this lays the foundation for further investigation, as this is a new result that deviates from previous research. We encourage further investigation of *Taraxacum officinale* by other researchers.

5. Limitations of the Study

The study was limited in that antimicrobial resistant strains of *Enterobacter cloacae* could not be specifically tested due to biohazard security concerns. Further work must be done in a secure facility to test the antimicrobial properties of *Taraxacum officinale* against drug resistant strains of *Enterobacter cloacae*.

6. Conflicts of Interest: The authors of this article do not have any conflicts of interest regarding this research.

7. Author Contribution

Conceptualization, PNA; Data curation, TP; Investigation, ANM, PLT and PNA; Methodology, PNA; Writing – original draft, TP and JS; Visualization, JS; Writing – review & editing, JS and PNA

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