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Antimicrobial Properties of Selected Plant Species within the Asteraceae Family †

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Abstract: The Asteraceae family is the largest family of flowering plants, comprising over 25,000 species grouped into 16,000 genera and distributed around the world. This research aimed to evaluate the antibacterial effectiveness of 12 native plants from the Asteraceae family. Their efficacy was tested against 11 bacterial strains using the liquid microdilution technique to determine the minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC). MIC values ranged from 0.125 to 4 mg/mL, and MBC values ranged from 0.25 to 4 mg/mL, against six bacterial strains. These results describe the potential antibacterial activity attributes of Asteraceae species.

Keywords: Asteraceae; *Helichrysum*; *Catatia*; microdilution

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1. Introduction

Asteraceae is the world's largest flowering plant family, with 1700 genera structured into 17 tribes [1]. In total, 26,000 different plant species are represented in the global distribution [2], 750 of which are native to Madagascar [3]. These plants flowers and leaves have been shown to have antibacterial, antifungal, antiviral, and anti-inflammatory activities [4]. For this reason, many different species in this family are used in traditional medicine. Plants in this study such as eleven species of *Helichrysum* and one species of *Catatia* are used in Malagasy traditional medicine. The aims of this study were to demonstrate that these plants from Asteraceae had antibacterial activity and could be a source of antibacterial agents. To reach that goal, the antibacterial activities of these plant extracts against 11 strains were evaluated using the microdilution method.

2. Materials and Methods

The plant materials used consisted of the aerial parts of *Helichrysum bojeranum*, *Helichrysum chermezonii*, *Helichrysum cordifolium*, *Helichrysum cryptomerioides*, *Helichrysum dubardii*, *Helichrysum faradifani*, *Helichrysum fulvescens*, *Helichrysum gymnocephalum*, *Helichrysum hirtum*, *Helichrysum microcephalum*, *Helichrysum mutisiaefolium*, and *Catatia cordata*. These plants were collected and identified by researchers at the Department of Enthobotany and Botany of the National Centre for the Application of Pharmaceutical Research (CNARP), Madagascar (Figure S1 in Supplementary Material). The voucher specimens were deposited at the herbarium of the aforementioned department. The harvested aerial parts were dried in a ventilated room at 30 °C and then ground into powder.

The aerial parts were extracted via maceration with methanol for 24 h at room temperature until exhaustion.

The broth microdilution method was used to determine the MIC (minimum inhibitory concentration) values in 96-well plates [5]. All methanolic extracts were assessed against five Gram-positive (*Bacillus cereus* LMG6910, *Bacillus megaterium* ATCC8145, *Listeria monocytogenes* ATCC19114TM, *Staphylococcus aureus* ATCC11632, and *Streptococcus pneumoniae* ATCC6301) and six Gram-negative (*Enterobacter cloacae* ATCC13047, *Escherichia coli* ATCC8739, *Klebsella oxytoca* ATCC8721, *Proteus mirabilis* ATCC35659, *Pseudomonas aeruginosa* ATCC10145, and *Salmonella enteritidis* ATCC3710) bacteria. All extracts were two-fold serially diluted using Muller–Hinton broth in the wells of the microtitration plates (from 4 to 0.0019 mg/mL), and the bacterial suspensions were then added (1.5×10^7 bacteria/mL), followed by overnight incubation at 37 °C. The MIC value was obtained by identifying the lowest concentration of the test sample that inhibited visible bacterial growth. The MBC value corresponded to the lowest concentration of the test sample that can kill bacteria, so no bacterial growth would be observed on the agar.

3. Results

The Asteraceae family is the most diverse and globally present of all flowering plant families. Their extracts have been proven in studies to have an effect on bacterial growth [6]. Table 1 shows the MICs and MBCs of each plant's extract. Extracts of *H. microcephalum* and *H. dubardii* were ineffective against all strains tested. Extracts of *H. bojeranum*, *H. cordifolium*, *H. chermezonii*, *H. faradifani*, *H. fulvescens*, *H. gymnocephalum*, *H. hirtum*, *H. mutisiaefolium*, and *C. cordata* were active against two Gram-negative strains (*E. cloacae* and *P. mirabilis*) and four Gram-positive strains (*L. monocytogenes*, *B. cereus*, *B. megaterium*, and *S. pneumoniae*), but they are inactive against other strains such as *S. aureus*, *E. coli*, *P. aeruginosa*, *K. oxytoca*, and *S. enteritidis*. These MICs against Gram-positive strains were between 0.125 and 4 mg/mL, but their MBC ranged from 0.25 to 4 mg/mL. According to Marmonier [7], if the MBC/MIC is $\leq$4, the extract is bactericidal, and if the MBC/MIC is >4 is bacteriostatic. Thus, extracts of *H. bojeranum*, *H. faradifani*, *H. fulvescens*, and *H. gymnocephalum* have bactericidal activity against two Gram-negative strains and four Gram-positive strains. *E. cloacae* was sensitive to *H. chermezonii* extract with bacteriostatic action. *H. cordifolium* extract is bactericidal against three Gram-positive strains *(L. monocytogenes*, *S. pneumoniae*, and *B. megaterium*), although it reveals bacteriostatic activity against *P. mirabilis*. Also, *H. hirtum* extract is bactericidal against four strains (two Gram-positive strains: *B. cereus* and *L. monocytogenes*; and two Gram-negative strains: *E. cloacae* and *P. mirabilis*) and shows bacteriostatic activity against *B. megaterium.* *H. mutisiaefolium* extract was found to be bactericidal against *L. monocytogenes*, a Gram-positive strain. *C. cordata* extract revealed bacteriostatic activity against *L. monocytogenes* and bactericidal activity against five strains (*B. cereus*, *B. megaterium*, *S. pneumonia*, *E. cloacae*, *and P. mirabilis*).

Table 1. Minimal inhibitory concentration (I) and minimum bactericidal concentration (B) of extracts from some Asteraceae species on six microorganisms.

Organism	*B. cereus*			*B. megaterium*			*L. monocytogenes*			*S. pneumoniae*			*E. cloacae*			*P. mirabilis*		
	I *	**B ***	**B/I**	**I**	**B**	**B/I**	**I**	**B**	**B/I**	**I**	**B**	**B/I**	**I**	**B**	**B/I**	**I**	**B**	**B/I**
C. cordata	1	2	2	1	4	4	0.25	4	16	2	1	0.5	1	2	2	1	4	4
H. bojeranum	2	4	2	2	4	2	2	4	2	-	-	-	2	4	2	2	4	2
H. chermezonii	-	-	-	-	-	-	-	-	-	-	-	-	2	4	2	-	-	-
H. cordifolium	-	-	-	1	2	2	0.125	0.25	2	2	1	2	-	-	-	0.125	2	16

Table 1. *Cont.*

Organism	*B. cereus*			*B. megaterium*			*L. monocytogenes*			*S. pneumoniae*			*E. cloacae*			*P. mirabilis*		
	I *	B *	B/I	I	B	B/I	I	B	B/I	I	B	B/I	I	B	B/I	I	B	B/I
H. cryptomerioides	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-
H. dubardii	4	-	-	4	-	-	-	-	-	-	-	-	4	-	-	4	-	-
H. faradifani	1	4	4	1	4	4	0.25	2	8	2	1	0.5	1	2	2	1	4	4
H. fulvescens	2	4	2	-	-	-	1	2	2	2	1	0.5	2	4	2	2	4	2
H. gymnocephalum	2	4	2	4	-	-	2	4	2	4	-	-	2	4	2	2	4	2
H. hirtum	2	4	2	0.5	4	8	1	2	2	-	-	-	1	4	4	2	4	2
H. microcephalum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
H. mutisiaefolium	-	-	-	4	-	-	2	4	2	-	-	-	-	-	-	-	-	-

I = MIC: minimal inhibitory concentration, B = MBC: minimum bactericidal concentration, * concentration in mg/mL.

4. Discussion

This research conducted by Boubekeur et al. [8] on the aqueous extract of *Helichrysum stoechas* prepared via maceration; its MIC on *K. pneumonia* is only 1.250 to 5 mg/mL and is inactive against *E. coli*, *S. aureus*, and *B. cereus*. Bactericidal activity against *B. cereus* and *L. monocytogenes* was reported in wild edible Asteraceae from Mediterranean flora (*Reichardia picroides*, *Hymenonema graecum*, *Sonchus oleraceus*, *Scolymus hispanicus*, *Hedypnois cretica*, *Picris echioides*, *Urospermum picroides*, and *Taraxacum sp.*, with MIC values varying from 0.075 to 0.3 mg/mL) [9], the same as our extracts (*C. cordata*, *H. bojeranum*, *H. faradifani*, *H. fulvescens*, *H. gymnocephalum*, and *H. hirtum*, with MIC values ranging from 1 to 4 mg/mL) that have bactericidal activity against these strains, with *B. cereus* and *L. monocytogenes*. However, according to Kuete and Efferth [10], a scale for antibacterial activity is given for plant extracts. It is said that extracts are significantly active if their MIC values are $\leq$100 µg/mL, moderately active if 100 < MIC $\leq$ 625 µg /mL, and weakly active if the MIC is >625 µg/mL. Therefore, *H. cordifolium*, *H. faradifani*, and *C. cordata* are moderately active on *L.* monocytogenes. The other extracts are weakly active on the strains tested. Nevertheless, it should be stated that plants show contrasting antibacterial activities due to differences in species, producing areas, harvest seasons, parts used, and extraction methods. Compared to chemical antibacterial agents, herbal products show low efficiency for bacteriostasis and sterilization, as well as poor antibacterial specificity.

5. Conclusions

The results show the *Helichrysum* and *Catatia* species, among the Asteraceae family, endemic to Madagascar have antibacterial activity. Even with the weak activities of most of the extracts studied, there is still a need to isolate and identify more small molecular compounds with potent bioactivity within those extracts. Undeniably, medicinal phytochemicals will play an important role in future discoveries of new drugs; nonetheless, only a small percentage of them have been studied.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/ECM2023-16410/s1, Figure S1: Species collection sites.

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