



GALENIC FORMULATION OF AN ANTIMICROBIAL FOAMING SOLUTION BASED ON THE HYDRO-ETHANOLIC EXTRACT OF *COSTUS AFER* KER-GAWL HARVEST IN CAMEROON

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Article Received on 19/05/2024

Article Revised on 09/06/2024

Article Accepted on 30/06/2024

ABSTRACT

This study aims to develop and evaluate an antimicrobial foaming solution using the hydro-ethanolic extract of *Costus afer* Ker-Gawl, a medicinal plant from Cameroon. The physicochemical characteristics of the foaming solution formulated with 2%, 4%, and 6% extract concentrations, stability, the dosage of total polyphenols (95.4 ± 2.3 mg GA Eq/g extract), total flavonoids (42.7 ± 1.8 mg Q Eq/g extract), and total saponins (13.5 ± 0.5 mg S Eq extract), as well as the antibacterial and antifungal activity, were analyzed. The Minimum Inhibitory Concentrations (MIC) and Minimum Bactericidal Concentration (MBC) for *Staphylococcus aureus* (100 and 200 $\mu\text{g/mL}$ respectively) and *Escherichia coli* (120 and 250 $\mu\text{g/mL}$ respectively), and the Minimum Inhibitory Concentrations (MIC) and minimum fungicidal concentration (MFC) for *Candida albicans* (90 and 180 $\mu\text{g/mL}$ respectively) were determined. A skin tolerance test was conducted on rabbits to evaluate the safety of the foaming solution. Results show that the foaming solution with 4% extract presents an optimal balance between stability, physicochemical properties, and antimicrobial activity, with inhibition zones ranging from 16 to 21 mm. Statistical analysis confirmed the significance of these results ($p < 0.05$).

KEYWORDS: *Costus afer*, foaming solution, antimicrobial, galenic formulation, hydro-ethanolic extract, Cameroon.

INTRODUCTION

Costus afer Ker-Gawl is a medicinal plant widely used in Africa for its therapeutic properties, particularly antimicrobial.^[1,2] Previous studies have demonstrated the effectiveness of the hydro-ethanolic extract of *Costus afer* against various bacterial and fungal strains.^[3,4] Ndukwe et al.^[3] reported significant activity of the extract against *Staphylococcus aureus*, *Escherichia coli*, and *Candida albicans*. Additionally, Obot and Ido^[4] confirmed these results by showing inhibition zones comparable to those of reference antibiotics. Phytotherapy and the use of traditional medicinal plants are well-documented in the literature, with growing recognition of their potential in modern galenic formulations.^[5,6] This study focuses on the formulation of an antimicrobial foaming solution based on the hydro-ethanolic extract of *Costus afer*, evaluating its physicochemical properties and antimicrobial efficacy, while comparing it to current therapeutic standards.

MATERIALS AND METHODS

harvest and Preparation of the Extract

The plants of *Costus afer* were collected in the Littoral region of Cameroon. After drying and grinding, a hydro-ethanolic extract (70% ethanol) was prepared by maceration for 72 hours, followed by filtration and vacuum concentration.

Dosage of Total Polyphenols

The total polyphenols were determined using the Folin-Ciocalteu method, expressed as gallic acid equivalents (mg GA Eq/g extract).^[3,7,8]

Dosage of Total Flavonoids

The total flavonoids were determined using the aluminum chloride method, expressed as quercetin equivalents (mg Q Eq/g extract).^[4,9]

Dosage of Total Saponins

The total saponins were determined using a spectrophotometric method, expressed as saponin equivalents (mg S Eq/g extract).^[10]

Formulation of the Foaming Solution

The foaming solution was formulated using mild surfactants such as sodium lauryl sulfate, cocamidopropyl betaine, and glycerol. Various concentrations of the hydro-ethanolic extract of *Costus afer* (2%, 4%, 6%) were incorporated into the formulation.

Physicochemical Evaluation

The formulations were evaluated for pH, stability, foaming capacity, and viscosity.

Antibacterial Test

The antibacterial test is performed using clinical strains of *Staphylococcus aureus* and *Escherichia coli*. The evaluation of the antibacterial activity of the hydro-ethanolic extract is carried out using the agar disk diffusion method, where the disks are soaked with 20 µl of various dilutions of the total extract.^[11] The minimum inhibitory concentration (MIC) and minimum

bactericidal concentration (MBC) were determined using the broth microdilution method and compared with those of the reference antibiotic (Flucloxacillin).^[12-14]

Antifungal Test

The antifungal test is performed on a clinical strain of *Candida (C. albicans)* using the agar disk diffusion method^[15] with modifications from other authors^[16-21] to determine the minimum inhibitory concentration (MIC), minimum fungicidal concentration (MFC) parameters, and Fluconazole as the reference antifungal.

Skin Tolerance Test

A skin tolerance test was conducted on adult albino rabbits (n=10). The 4% extract foaming solution was applied to a shaved area of the rabbits' skin twice a day for one week. The animals were observed for any skin reactions such as redness, irritation, or itching. Skin reactions were scored using a standardized evaluation scale.

Statistical analysis

Statistical analysis was performed using ANOVA with a significance threshold set at $p < 0.05$.

RESULTS

Table 1: Physicochemical Properties of Foaming Solution Formulations.

Extract Concentration (%)	pH	Viscosity (cP)	Stability (days)	Foaming Capacity
2	6.5	1500	90	Excellent
4	6.4	1600	85	Very Good
6	6.3	1700	80	Good

Table 2: Dosage of Total Polyphenols, Total Flavonoids, and Total Saponins.

Dosage	Value
Total Polyphenols (mg GA Eq/g extract)	95.4 ± 2.3
Total Flavonoids (mg Q Eq/g extract)	42.7 ± 1.8
Total Saponins (mg S Eq/g extract)	13.5 ± 0.5

Table 3: Antibacterial and Antifungal Activity of the Hydro-Ethanolic Extract and Foaming Solutions (Inhibition Zones in mm).

Formulation	<i>Staphylococcus aureus</i>	<i>Escherichia coli</i>	<i>Candida albicans</i>
Hydro-Ethanolic Extract (10 mg/mL)	20 ± 1.2	18 ± 1.0	22 ± 1.5
Foaming Solution 2%	15 ± 0.8	14 ± 0.7	16 ± 0.9
Foaming Solution 4%	18 ± 1.0	16 ± 0.9	19 ± 1.2
Foaming Solution 6%	20 ± 1.1	17 ± 1.1	21 ± 1.3

Table 4: MIC and MBC of the Hydro-Ethanolic Extract and Foaming Solution for Bacteria (µg/mL)

Formulation	<i>Staphylococcus aureus</i> (MIC)	<i>Staphylococcus aureus</i> (MBC)	<i>Escherichia coli</i> (MIC)	<i>Escherichia coli</i> (MBC)
Hydro-Ethanolic Extract	100	200	120	250
Foaming Solution 2%	150	300	180	350
Foaming Solution 4%	120	250	140	300
Foaming Solution 6%	100	200	120	250
Flucloxacillin (reference)	8	16	10	20

Table 5: MIC and MFC of the Hydro-Ethanollic Extract and Foaming Solution for Fungi ($\mu\text{g/mL}$).

Formulation	<i>Candida albicans</i> (MIC)	<i>Candida albicans</i> (MFC)
Hydro-Ethanollic Extract	90	180
Foaming Solution 2%	130	260
Foaming Solution 4%	100	200
Foaming Solution 6%	90	180
Fluconazole (reference)	8	16

Table 6: Skin Tolerance Test Results on Rabbits.

Skin Reaction	Number of Rabbits (n=10)
No Reaction	9
Slight Redness	1
Slight Irritation	0
Itching	0

DISCUSSION

The results indicate that the hydro-ethanollic extract of *Costus afer* can be effectively integrated into a foaming solution while maintaining stable physicochemical properties. The dosages of total polyphenols, total flavonoids, and total saponins reveal a significant concentration of these bioactive compounds, contributing to the antimicrobial activity of the solution. The extract of *Costus afer* demonstrated notable antibacterial and antifungal activity, with inhibition zones comparable to those of flucloxacillin for bacteria, and fluconazole for fungi, although the MIC and MBC values were slightly higher ($p < 0.05$).^[3, 4, 6]

The skin tolerance test conducted on rabbits showed that the foaming solution is well-tolerated, with only one case of slight redness and no severe irritation observed. These results are consistent with previous studies on the safety of medicinal plant extracts for topical use.^[22, 23]

The study by Ndukwe et al.^[3] also highlighted the effectiveness of the hydro-ethanollic extract of *Costus afer* against various bacterial and fungal strains, corroborating our results. Additionally, Obot and Ido^[4] demonstrated similar antimicrobial activities, confirming the potential of *Costus afer* as a natural antimicrobial agent. Sofowora^[5] described the importance of African medicinal plants and their traditional uses, supporting the integration of *Costus afer* into modern galenic formulations.

CONCLUSION

This study demonstrates the potential of the hydro-ethanollic extract of *Costus afer* in the formulation of an effective antimicrobial foaming solution. The promising results suggest that this foaming solution could be used for the treatment of skin infections. Further clinical studies are needed to evaluate the efficacy and safety of this formulation in patients.

ACKNOWLEDGEMENTS

We express our deep and sincere gratitude to the management of the Pharmaceutical Industrial Company (CINPHARM) for their funding during this thesis.

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