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Comparative Analysis of the Effects of Moringa Oleifera Leaf Extract and Ciprofloxacin On Ocular Bacteria Infection in Owerri, Imo State

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Abstract- ***Ocular bacterial infections are a major cause of bacteria-associated conjunctivitis and may culminate in visual impairment and blindness. The disease is treated with topical antibiotics. However, the emergence of antibiotic drug resistance in ocular infections undermines successful treatment, and alternative interventions using natural remedies are advocated. This study compared the effectiveness of Moringa oleifera leaf extract and ciprofloxacin in the treatment of ocular bacterial infections. The study was conducted at the Molecular and Biochemistry Laboratory of the Federal University of Technology, Owerri, Imo State. It adopted an experimental design involving twenty-four adult Wistar rats grouped into four groups: Group A (not infected, not treated), Group B (infected, not treated), Group C (infected and treated with Moringa oleifera leaf extract), and Group D (infected and treated with ciprofloxacin). Moringa oleifera leaf extract was prepared using the Soxhlet extraction method. Different concentrations of the extract (100 mg/ml, 75 mg/ml, 50 mg/ml) and ciprofloxacin were prepared to determine the minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) against ocular bacterial isolates (Staphylococcus aureus and Streptococcus pyogenes). Data were analysed using appropriate statistical tools. The level of significance was set at $P < 0.05$. Moringa oleifera leaf extract contains flavonoids, saponins, alkaloids, tannins and phenols and showed antibacterial activity ($P = 0.001$). Quantitative analysis revealed flavonoids as the most abundant (1258.07 ± 13.30 µg/g), followed by phenols (560.47 ± 10.03 µg/g) and saponins (456.53 ± 5.62 µg/g). Tannins (20.07 ± 0.44 µg/g) and alkaloids (8.20 ± 0.35 µg/g) were present in lower amounts. At 3 mg/ml, 2 mg/ml and 1.5 mg/ml, Moringa extract produced zones of inhibition of 34.67 ± 0.57 mm, 27.33 ± 1.16 mm and 16.33 ± 0.58 mm against Streptococcus pyogenes, and 17.67 ± 2.52 mm, 18.00 ± 1.00 mm and 9.67 ± 1.53 mm against Staphylococcus aureus. Ciprofloxacin at the same concentrations produced 24.67 ± 3.51 mm, 22.67 ± 0.58 mm and 20.00 ± 1.00 mm against Streptococcus pyogenes, and 43.33 ± 3.52 mm, 32.33 ± 0.58 mm and 27.67 ± 2.52 mm against Streptococcus aureus. The findings show that Moringa oleifera leaf extract possesses significant antibacterial properties and may serve as an alternative treatment option for ocular bacterial infections. The study recommends that the leaf extract be formulated into an eye drop for the treatment of ocular bacterial infections.***

Keywords: ***Moringa oleifera, Ciprofloxacin, Ocular bacterial infection, Staphylococcus aureus, Streptococcus pyogenes, Antibacterial activity.***

I. INTRODUCTION

Ocular bacterial infections are a major cause of bacteria-associated conjunctivitis and may progress to visual impairment or blindness if untreated [1], [19]. The condition is commonly managed with topical antibiotics such as ciprofloxacin [11], [21]. However, the rising incidence of antibiotic resistance has reduced the effectiveness of conventional therapy and created a need for alternative treatment options [2], [20]. Moringa oleifera (commonly called the drumstick or miracle tree) is a plant widely used in traditional medicine. Its leaves contain bioactive compounds including flavonoids, phenols, saponins, alkaloids and tannins that possess antioxidant, anti-inflammatory and antimicrobial properties [3], [4], [17], [18]. Previous studies have demonstrated antibacterial activity of Moringa oleifera extracts against several pathogens [5], [6], [10], [15], yet comparative data specifically against ocular isolates of Staphylococcus aureus and Streptococcus pyogenes remain limited, particularly in the Nigerian setting. Toxicological studies have shown that Moringa oleifera leaf extracts have a relatively high

safety margin [12], [13], [14], [22], [23], [24]. This study was therefore designed to compare the antibacterial effects of ethanolic Moringa oleifera leaf extract with ciprofloxacin against ocular bacterial pathogens using both in vitro and in vivo approaches.

II. MATERIALS AND METHODS

A. Study Design and Location

The study was an experimental design conducted at the Molecular and Biochemistry Laboratory of the Federal University of Technology, Owerri, Imo State.

B. Experimental Animals

Twenty-four adult Wistar rats of both sexes weighing 150–200g were used. The animals were acclimatized for fourteen days and randomly allocated into four groups of six rats each:

Group A: Normal control (not infected, not treated)

Group B: Negative control (infected, not treated)

Group C: Infected and treated with Moringa oleifera leaf extract

Group D: Infected and treated with ciprofloxacin

Ethical approval was obtained from the institutional animal ethics committee. Previous studies have also used Wistar rats for evaluating the safety and effects of Moringa oleifera extracts [14], [22].

C. Plant Material and Extraction

Fresh Moringa oleifera leaves were authenticated, washed, dried and powdered. Ethanolic extraction was performed using the Soxhlet apparatus. The extract was concentrated and stored for further use.

D. Phytochemical Analysis

Qualitative and quantitative phytochemical analyses were performed using standard methods to determine the presence and concentrations of flavonoids, phenols, saponins, alkaloids and tannins [7], [8].

E. Bacterial Isolates and Antimicrobial Assays

Clinical isolates of Staphylococcus aureus and Streptococcus pyogenes were standardized to 0.5 McFarland turbidity. Agar well diffusion and broth dilution methods were used to determine zones of inhibition, minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) at extract concentrations of 1.5 mg/ml, 2.0 mg/ml and 3.0 mg/ml. Ciprofloxacin served as the positive control [9].

F. Induction of Ocular Infection and Treatment

Bacterial conjunctivitis was induced by instilling standardized inocula of the test organisms into the conjunctival sac under anaesthesia. Treatment was administered topically. Clinical recovery and bacterial clearance were monitored. Related studies have also examined the ocular effects of Moringa oleifera [16].

G. Statistical Analysis

Data were analysed using SPSS version 22. One-way ANOVA and post-hoc tests were applied. Statistical significance was set at $P < 0.05$.

III. RESULTS

A. Phytochemical Composition

Quantitative analysis of the ethanolic Moringa oleifera leaf extract revealed flavonoids as the most abundant compound (1258.07 ± 13.30 µg/g), followed by phenols (560.47 ± 10.03 µg/g) and saponins (456.53 ± 5.62 µg/g). Tannins (20.07 ± 0.44 µg/g) and alkaloids (8.20 ± 0.35 µg/g) were present in lower amounts. These findings are consistent with earlier phytochemical reports [4], [17], [18].

B. Antibacterial Activity

Moringa oleifera leaf extract produced dose-dependent zones of inhibition. At 3 mg/ml, 2 mg/ml and 1.5 mg/ml the extract yielded 34.67 ± 0.57 mm, 27.33 ± 1.16 mm and 16.33 ± 0.58 mm against Streptococcus pyogenes, and 17.67 ± 2.52 mm, 18.00 ± 1.00 mm and 9.67 ± 1.53 mm against Staphylococcus aureus.

Ciprofloxacin at the same concentrations produced 24.67 ± 3.51 mm, 22.67 ± 0.58 mm and 20.00 ± 1.00 mm against Staphylococcus pyogenes, and 43.33 ± 3.52 mm, 32.33 ± 0.58 mm and 27.67 ± 2.52 mm against Staphylococcus aureus.

The extract showed significantly higher activity against Staphylococcus pyogenes ($P < 0.05$), while ciprofloxacin was superior against Staphylococcus aureus. These results support previous reports of the antibacterial potential of Moringa oleifera [5], [6], [10], [15].

C. Minimum Inhibitory and Bactericidal Concentrations

MIC of the extract was 3 mg/ml for Staphylococcus pyogenes and 2 mg/ml for Staphylococcus aureus. Ciprofloxacin had a lower MIC of 1.5 mg/ml against both organisms. No clear MBC was recorded for the extract within the tested range, indicating a primarily bacteriostatic effect.

D. In Vivo Recovery

Ciprofloxacin produced faster clinical recovery (approximately 3–7 days). The extract achieved progressive bacterial clearance, with faster recovery against Staphylococcus pyogenes (6–10 days) than against Staphylococcus aureus.

IV. DISCUSSION

The high flavonoid and phenolic content of the ethanolic extract is consistent with earlier reports and provides a biochemical basis for the observed antibacterial activity [3], [4], [10], [17]. The selective superiority of Moringa oleifera extract against Streptococcus pyogenes is clinically relevant because streptococcal conjunctivitis is common [1], [19]. Ciprofloxacin's stronger activity against Staphylococcus aureus reaffirms its established role as a first-line agent [11], [21].

The primarily bacteriostatic nature of the extract at the concentrations tested suggests it may be most useful as an adjunct therapy or for mild-to-moderate streptococcal infections, especially in settings where fluoroquinolone resistance or limited access is a concern [2], [20].

Toxicological studies have confirmed the relative safety of Moringa oleifera leaf extracts at moderate doses [12], [13], [14], [22], [23], [24], [25]. Preliminary safety observations in the present study support further development of sterile ophthalmic formulations. Related work has also examined ocular applications of Moringa [16]. Future studies should evaluate Gram-negative ocular pathogens, long-term resistance potential and clinical formulations.

V. CONCLUSION

Ethanolic Moringa oleifera leaf extract possesses quantifiable bioactive phytochemicals and demonstrates significant antibacterial activity, particularly against Streptococcus pyogenes. While ciprofloxacin remains more potent overall, the plant extract represents a promising candidate for development as an adjunct or alternative topical agent for ocular bacterial infections. Formulation into a stable sterile eye drop and further clinical evaluation are recommended.

Declaration by Authors

Ethical Approval: Approved by the Animal Ethics Committee of the Federal University of Technology, Owerri.

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