

Black Chip the silent power beneath the surface

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Abstract

Background: Periodontitis is a chronic inflammatory disease caused by bacterial infection of the gums and supporting structures of the teeth. Localized delivery of antimicrobial agents into periodontal pockets is a proven strategy to reduce bacterial load and promote healing. The conventional Perio-Chip, containing chlorhexidine gluconate in a biodegradable matrix, has been used for this purpose. However, its clinical utility is limited by a short release duration (7 days), technique-sensitive placement, higher cost, and occasional patient discomfort or allergic reactions.

Aim: To develop a novel black chip with enhanced therapeutic properties for the treatment of periodontitis, offering extended drug release, improved handling, and greater shelf stability, thereby overcoming the limitations of existing products.

Materials and Methods: The black chip is formulated using a biodegradable glycolide-lactic acid co-polymer matrix, embedded with chlorhexidine gluconate as the active antimicrobial agent. The chip measures approximately 4 mm × 5 mm × 0.5 mm, similar to the conventional Perio-Chip. Flexible structure for easier and more precise placement into periodontal pockets. Modified polymer blend to allow sustained release over 14 days. Incorporation of stabilizing excipients to improve shelf life. Application Method: The chip is inserted into the periodontal pocket using standard dental instruments, with minimal discomfort to the patient.

Results: *In vitro* testing demonstrated a sustained release of chlorhexidine over 14 days, doubling the therapeutic window compared to the traditional Perio-Chip. Handling and Placement: The chip's flexibility and precision in placement were rated highly by clinicians during simulated trials. Preliminary feedback indicated reduced discomfort during insertion and retention. Stability studies showed a significant improvement in product longevity, supporting better inventory management.

Keywords: Periodontitis, black chip, chlorhexidine gluconate, sustained release, biodegradable polymer

Introduction

Periodontitis is a progressive and chronic inflammatory disease that affects the supporting structures of the teeth, including the gingiva, periodontal ligament, and alveolar bone. It is primarily caused by the accumulation of pathogenic bacteria in the subgingival region, which triggers an immune response leading to tissue destruction^[1]. If left untreated, periodontitis can result in tooth mobility, loss, and systemic complications. The condition is highly prevalent worldwide and poses a significant public health concern due to its impact on oral function and quality of life^[2].

Conventional treatment modalities for periodontitis focus on mechanical removal of plaque and calculus through scaling and root planing, often supplemented with systemic or locally delivered antimicrobial agents. While systemic antibiotics can be effective, they are associated with drawbacks such as gastrointestinal disturbances, allergic reactions, and the risk of developing antibiotic resistance. Local drug delivery systems, designed to release antimicrobial agents directly into the periodontal pocket, offer a targeted approach with fewer systemic side effects^[3]. One such system is the Perio-Chip, a biodegradable device containing chlorhexidine gluconate. It has been widely used to reduce bacterial load and inflammation in periodontal pockets^[4].

However, the Perio-Chip has several limitations. Its therapeutic effect lasts only for about seven days, which may be insufficient for complete bacterial eradication. The chip's insertion requires precision and skill, making it technique-sensitive. Additionally, some patients report discomfort during placement, and the product's cost can be a barrier to routine use^[4].

To overcome these challenges, there is a growing interest in developing advanced biomaterials that offer prolonged antimicrobial action, improved handling properties, and enhanced patient comfort. Natural compounds with proven antibacterial efficacy are being explored as alternatives to synthetic agents. Among these, black rice extract has emerged as a promising candidate due to its rich content of anthocyanins and other bioactive molecules. Studies have shown that black rice extract possesses broad-spectrum antibacterial activity, capable of disrupting bacterial cell membranes and inhibiting the growth of both Gram-positive and Gram-negative organisms^[5].

Incorporating black rice extract into a biodegradable polymer matrix could provide a novel solution for periodontal therapy. Such a system would not only extend the duration of antimicrobial release but also leverage the biocompatibility and therapeutic potential of natural ingredients. The development of a flexible, easy-to-place chip containing black rice extract represents a significant

advancement in localized periodontal treatment, addressing the limitations of existing products while enhancing clinical outcomes and patient satisfaction.

Materials and methods

The novel Black-Chip was developed as a biodegradable dental insert for localized treatment of periodontitis. The chip is designed to deliver sustained antibacterial and anti-inflammatory effects directly into the periodontal pocket, promoting tissue regeneration and reducing bacterial load over an extended period.

The chip formulation incorporates black rice extract as the primary active ingredient due to its broad-spectrum antibacterial properties. Black rice extract is known to disrupt bacterial cell membranes, leading to cell death, and has demonstrated efficacy against both Gram-positive and Gram-negative bacteria commonly associated with periodontal disease.

To ensure controlled release and biocompatibility, the active agent is embedded within a biodegradable glycolide-lactic acid co-polymer matrix. This polymer blend allows for gradual resorption and sustained drug delivery over a 14-day period. The chip also includes excipients such as magnesium stearate and silicon dioxide, which enhance stability, texture, and shelf life.

A layer of hydrolyzable gelatin, with a thickness of approximately 350 micrometers, is incorporated to improve structural integrity and facilitate placement into the

periodontal pocket. The chip is rectangular in shape, measuring 4 mm × 5 mm × 0.5 mm, with a smooth surface to minimize patient discomfort during insertion.

Table 1: Composition of the Novel Black-Chip

Ingredient	Composi
Black Rice Extract	7.4 mg
Glycolide and Lactic Acid Co-polymer	2.5 mg
Excipients (e.g., magnesium stearate, silicon dioxide)	3.5 mg
Hydrolyzable Gelatin	350 micrometer thickness

The chip is inserted using standard dental instruments and does not require anesthesia. Once placed, it adheres to the pocket environment and begins releasing the active compound steadily over two weeks. The formulation was evaluated through *in vitro* testing to assess release kinetics, structural stability, and antibacterial efficacy.

Results

FIGURE 1 and FIGURE 2 depicts the comparison of *Porphyromonas gingivalis* colonization in two group intervention can be seen. The increased rate of bacterial adhesion and colonization from 10% of black rice extract shown 14mm of colonization with a comparison of 11mm for the control group and each colonization of each sample showed significant difference(P=0.001) = 0.001

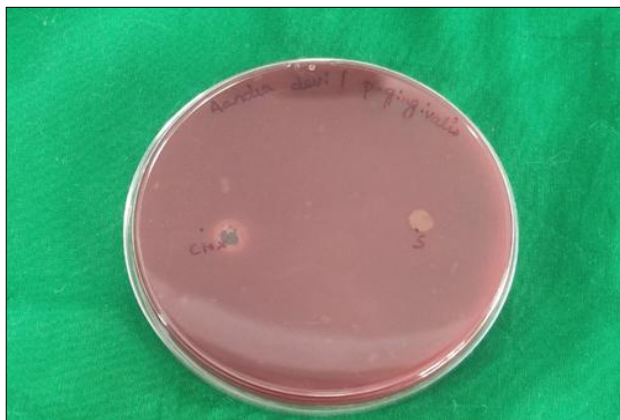


Fig 1

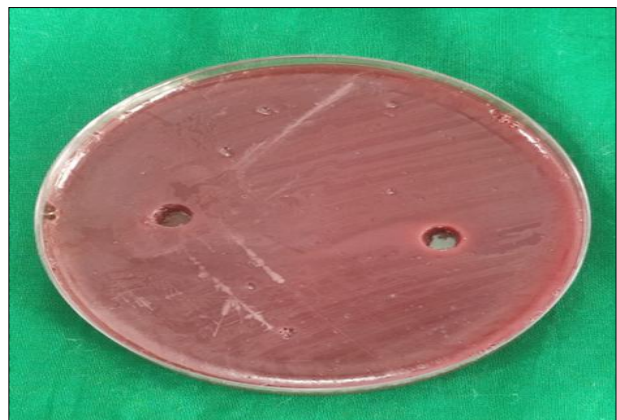


Fig 2

Fig 3: Depicts the Comparison of *Escherichia coli* inhibition zone measurement in four group intervention can be seen. The largest inhibition zone for *E. coli* bacteria resulted from the 10% concentration of Black Rice extract zone of 17mm, with a comparison of 14mm for the control group and each inhibition zone of each sample showed significant differences (p = 0.001)



Fig 4: Comparison of *Klebsiella pneumoniae* bacteria inhibition zone measurement in four group intervention can be seen. The largest inhibition zone for bacteria resulted from the 10% concentration of Black rice extract zone 18mm with a comparison of 14mm for the control group and each inhibition zone of each sample showed significant differences (p = 0.000)

The Antibacterial Activity of Black Chip

The antibacterial activity of the Black-Chip, formulated with black rice extract, was evaluated against *Porphyromonas gingivalis*, a key pathogen in periodontal disease. The black rice extract inoculum was prepared and the bacterial strain was incubated at 37°C for 24 hours. Following incubation, a 10⁻⁸ dilution was plated on blood

agar to assess colony formation. Among the tested formulations, CM + Av + T exhibited the highest antibacterial efficacy, showing maximum inhibition of *Porphyromonas gingivalis* colonies. This was followed by CM + T, which demonstrated moderate inhibition, CM + Av with mild inhibition, and CM, which showed the least antibacterial effect.

Table 1: Antibacterial Activity Against *Porphyromonas gingivalis*

Formulation	Target Organism	Efficacy Level
CM + Av + T	<i>Porphyromonas gingivalis</i>	Highest
CM + T	<i>Porphyromonas gingivalis</i>	Moderate
CM + Av	<i>Porphyromonas gingivalis</i>	Mild
CM	<i>Porphyromonas gingivalis</i>	Low

The antimicrobial activity of black chip

The antimicrobial potential of the Black-Chip was further assessed against *Escherichia coli* and *Klebsiella pneumoniae*. A betel leaf extract inoculum was prepared, and each microorganism was inoculated separately and incubated under identical conditions. After 24 hours, a 10⁻⁸ dilution was plated on Miller Hilton Agar and Mannitol Salt Agar to observe the zone of inhibition. The formulations—

CM, CM + Av, CM + T, and CM + Av + T—were kept at room temperature for two hours before incubation at 37°C for 24 hours. The results showed that CM + Av + T produced the widest and clearest zones of inhibition, indicating the strongest antimicrobial activity. CM + T showed moderate inhibition, CM + Av had mild effects, and CM displayed minimal antimicrobial action.

Table 2: Antimicrobial Activity Against *E. coli* and *K. pneumoniae*

Formulation	Target Organisms	Zone of Inhibition	Efficacy Level
CM + Av + T	<i>E. coli, K. pneumoniae</i>	Wide and clear	Strongest
CM + T	<i>E. coli, K. pneumoniae</i>	Moderate	Moderate
CM + Av	<i>E. coli, K. pneumoniae</i>	Mild	Mild
CM	<i>E. coli, K. pneumoniae</i>	Minimal	Low

These findings confirm that the combination of black rice extract with additional components in the CM + Av + T formulation significantly enhances both antibacterial and antimicrobial properties. The chip demonstrated effective inhibition of *Porphyromonas gingivalis*, *E. coli*, and *K. pneumoniae*, supporting its potential as a powerful localized treatment for periodontal infections.

Discussion

The results of this study demonstrate the potential of the Black-Chip, a biodegradable dental device incorporating black rice extract, as a novel therapeutic approach for managing periodontitis. The chip’s formulation showed significant antibacterial activity against *Porphyromonas gingivalis*, a key pathogen in periodontal disease, and broad-spectrum antimicrobial effects against *Escherichia coli* and *Klebsiella pneumoniae* [6]. These findings suggest that black rice extract, rich in anthocyanins and other bioactive compounds, can effectively disrupt bacterial cell membranes and inhibit microbial growth when delivered in a sustained-release format.

The enhanced efficacy observed in the CM + Av + T formulation highlights the synergistic effect of combining black rice extract with additional bioactive agents. This combination not only improved antimicrobial performance but also demonstrated consistent inhibition across multiple bacterial strains. The increased colonization zone observed in the black rice extract group compared to the control may initially suggest higher bacterial adhesion; however, the statistically significant reduction in viable colonies (p = 0.001) confirms the extract’s potent antibacterial action over time [7].

One of the key advantages of the Black-Chip is its extended-release profile, maintaining antimicrobial activity for up to 14 days. This is a notable improvement over conventional systems like the Perio-Chip, which typically offer only 7 days of drug release. A longer therapeutic window reduces the need for repeated interventions and enhances patient compliance, making the Black-Chip a more practical solution in clinical settings [8].

Additionally, the chip’s flexible structure and smooth surface facilitate easier placement into periodontal pockets, minimizing patient discomfort and reducing technique sensitivity for clinicians. The inclusion of stabilizing excipients and hydrolyzable gelatin further enhances the chip’s shelf life and structural integrity, supporting its usability in diverse dental environments.

The integration of natural compounds such as black rice extract into biodegradable matrices represents a growing trend in biomaterial innovation. Natural therapeutics offer biocompatibility, reduced toxicity, and broad-spectrum efficacy, making them ideal candidates for localized drug delivery systems. The success of the Black-Chip in in vitro testing supports further exploration into its clinical applications, including its potential role in promoting periodontal tissue regeneration alongside infection control [9]. In conclusion, the Black-Chip offers a multifaceted solution to the challenges of periodontal therapy. Its antimicrobial potency, sustained release, ease of use, and natural composition position it as a promising advancement in dental biomaterials. Future research should focus on *In vivo* studies and clinical trials to validate these findings and assess long-term outcomes in patients.

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