THE EVALUATION OF DIFFERENT MODALITIES OF BIOPHOTONIC THERAPY FOR THE STERILIZATION OF ESCHERICHIA COLI

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SUMMARY

The sterilization of Escherichia coli (E. coli) represents a significant challenge in Medicine and the food industry, due to the potential for infection and disease spread. Traditional methods such as antibiotics and chemical disinfectants have limitations due to bacterial resistance and adverse effects. This manuscript reviews the use of biophotonic therapies as innovative alternatives for the inactivation of E. coli. The biophotonic approach uses light at specific wavelengths, associated with photosensitizing agents, to induce bacterial cell death. The study explores sterilization protocols based on laser, photodynamic therapy (PDT), and light-emitting diodes (LEDs), analyzing mechanisms of action, application parameters, and advantages compared to traditional methods. The methodology included the analysis of articles published in the last 10 years in the PubMed database, focusing on the sterilization of E. coli using biophotonic techniques, with descriptors such as "sterilization," "E. coli," "Laser," and "biophotonic therapy." The results highlight the effectiveness of different approaches. The use of methylene blue (MB) and sodium bicarbonate showed bactericidal effects, but with limitations; polymeric nanoparticles conjugated with croconaine (CR-PQAC) demonstrated efficacy under NIR light; curcumin proved promising for preserving food while maintaining sensory quality; and photodynamic therapy (aPDT) was comparable to conventional chemical disinfectants. With this literature review, it can be concluded that biophotonic technologies are effective in inactivating E. coli and offer ecological and efficient alternatives for microbial control.

Keywords: Laser; LED; Escherichia coli; Sterilization

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Introduction

The sterilization of pathogenic microorganisms, such as Escherichia coli (E. coli), remains a critical challenge in medicine and the food industry due to their potential to cause severe infections and spread diseases. (Giannelli et al., 2017) Traditionally, methods such as the use of antibiotics and chemical disinfectants have been the pillars in controlling these bacteria. However, the increasing bacterial resistance and the negative impacts associated with these methods, such as toxicity and side effects, underscore the urgent need to explore safer and more effective alternatives. (Giannelli et al., 2017)

In this scenario, biophotonic therapy has gained prominence as an innovative and promising approach for the inactivation of microorganisms. This technique uses the application of light at specific wavelengths, in combination with photosensitizing agents, to induce controlled bacterial cell death. Various modes of biophotonic therapy, such as laser, photodynamic therapy (PDT), and light-emitting diodes (LED), have been investigated for their ability to sterilize surfaces, equipment, and contaminated tissues (Ogasawara et al., 2019).

This literature review aims to critically discuss different E. coli sterilization protocols that utilize biophotonic therapies. The specific mechanisms of action of each protocol, the application parameters such as light intensity and duration, as well as the advantages and limitations associated with each technique will be discussed. Furthermore, the study highlights the potential of these biophotonic approaches compared to traditional methods, offering a comprehensive view of their role in microbial control in different contexts, from clinical settings to industrial applications.

Methodology

The articles included in this review were all extracted from the PubMed database. The inclusion criteria were articles in English published in the last 10 years

that detailed the process of sterilizing the E. coli bacteria by some biophotonic method. The descriptors sterilization, Escherichia coli, laser, and biophotonic therapy were used, according to Table 1.

Results

Table 1 Studies used in this systematic review

Name	Title	Objective	Result
(Ogasawara et al., 2019	Sterilization of Escherichia coli using a light-emitting diode and methylene blue	Examine the effect of methylene blue (MB) with sodium bicarbonate (NaHCO3) against E. coli using photodynamic antimicrobial chemotherapy (PACT).	The study shows that methylene blue (MB) with $NaHCO_3$ has bactericidal effects on E. coli by causing an acid-base disturbance at pH > 8.6. However, this approach is not suitable for intravascular application. The effect is due to the characteristics of PACT and the dye used.
(Zhang et al., 2023)	Cationic polymeric nanoparticles conjugated with croconaine for enhanced bacterial elimination by NIR	Evaluate croconaine to verify its potential for use in eliminating bacteria.	The thermal effect generated by CR-PQAC could effectively promote the elimination of methicillin-resistant Staphylococcus aureus (Gram-positive) and Escherichia coli (Gram-negative) bacteria under NIR light irradiation.
(Yu et al., 2021)	Effect of photodynamic treatments on the quality and antioxidant properties of	The study is a report on the antioxidant properties of potatoes prepared by the photodynamic bactericidal activity of	The study showed that curcumin-based PDT can inactivate E. coli in freshly cut potato slices with low curcumin concentration and limited exposure time,

	minimally processed potatoes	**curcumin. To eliminate E. coli and S. aureus from the potatoes.**	**maintaining product quality and enhancing nutritional value. PDT also affects enzymes such as PPO, POD, and PAL, having varied effects.**
(Fonseca et al., 2020)	**Antimicrobial Photodynamic Therapy (aPDT) for Decontamination of High-Speed Handpieces: A Comparative Study**	**Evaluate the decontamination of high-speed dental handpieces contaminated with SA and E. Coli, using aPDT, and compare it to the conventional chemical agents currently used in dental offices.**	**The experiment showed that the laser and the photosensitizer alone were not effective in inhibiting the growth of Staphylococcus aureus (SA) and Escherichia coli (EC), but when combined in the aPDT procedure, they can be compared to traditionally used and effective chemical disinfection agents against this pathogen.**
(Lin et al., 2018)	**Photodynamic sterilization based on curcumin for the preservation of fresh-cut Hami melon**	Determine if the application of photodynamic therapy has potential for the preservation of freshly cut Hami melon during storage at 4 °C.	**Curcumin can be used as a photosensitizer in photodynamic sterilization to preserve food. The study showed that 50 μmol/L of curcumin under blue LED light for 60 minutes can effectively sterilize bacteria in cut Hami melon, slowing down microbial growth and preserving its sensory qualities.**

Conclusion

The synthesis of the five texts reveals that technologies based on photosensitization, such as photodynamic sterilization with curcumin, methylene blue (MB), and cationic polymers conjugated with croconaine (CR-PQAC), are effective in inactivating bacteria like Escherichia coli. Curcumin has shown promise in food preservation, such as Hami melon and freshly cut potatoes, by eliminating microbes and maintaining the sensory quality of the products. The use of MB with $NaHCO_3$ demonstrated a bactericidal effect on E. coli by altering the pH, although limited to non-intravenous applications. CR-PQAC, when combined with NIR light, was effective against methicillin-resistant E. coli, also showing potential for wound healing. Moreover, the antibacterial treatment based on curcumin and PDT proved comparable to traditional chemical disinfectants, reinforcing its potential as an ecological and efficient alternative for the food and medical industries.

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