Exploring Innovative Opportunities to Improve Food Safety with Photodisinfection

TAKE HOME MESSAGES

- Photodisinfection is a technology that uses the application of a photosensitizer followed by light irradiation to destroy pathogens
- Photodisinfection is a proven technology being used for nasal decolonization to reduce the risk of infections in healthcare settings
- Research is underway to evaluate this technology for food decontamination and for sanitization of food matrices and contact surfaces
- There is potential for novel food industry sanitization methods that are safe, quick, effective, and do not require the use of antibiotics

FUNDAMENTALS OF PHOTODISINFECTION

The use of light as a therapy in medicine has a long history with records from ancient Greece, Egypt and India **(Deniell & Jill, 1991)**. The first evidence of cell death induced by the interaction of light and chemicals was documented by Oscar Raab in Munich, who noticed the combination of acridine red dye and light had a lethal effect on paramecium **(Raab, 1900)**. Continued work led to the development of first-generation sensitizers for treating skin tumours and tumours on the lining of internal organs **(Kessel, 2019)**. In recent years, photodynamic therapy has emerged as a non-invasive therapeutic option with numerous applications, from cancer treatments to microbial disinfection.

Photodisinfection is a multi-stage treatment that involves the administration of a light-sensitive substance, known as a photosensitizer, followed by light irradiation at a specific wavelength. This illumination activates the photosensitizer, which undergoes a transition from a low-energy state to an excited and cytotoxic state. The excited-state photosensitizer produces a cascade of free radicals that physically tear apart and destroy microbes. When the light is turned off, the reaction ceases. The use of positively charged photosensitizers ensures non-microbial cells are minimally affected. This helps protect human tissues from damage **(Loebel et al., 2016)**.

Antimicrobial resistance **(AMR)** is a significant and growing global concern. Not only is photodisinfection effective against multidrug-resistant organisms but, unlike with antibiotics and other traditional antimicrobials, pathogens do not develop resistance with repeat exposure to this technology **(Tavares et al., 2010)**. Photodisinfection is a particularly valuable strategy for killing biofilms—complex microbial ecosystems formed by one or more species immersed in an extracellular matrix—which can be resistant to antimicrobials.

APPLICATIONS IN HEALTHCARE

Photodynamic therapy and photodisinfection have a long clinical history in the treatment of malignant cancers and localized infections of the skin and oral cavity. Photodisinfection has been found to be effective in the treatment of a variety of bacterial, fungal and viral infections including human papilloma virus, acne, brain abscesses, folliculitis, skin ulcers, interdigital mycosis, and candidiasis **(Loebel et al., 2020)**. In dentistry, photodisinfection has become a well-established therapy to combat harmful oral bacteria and treat periodontitis **(Joseph et al., 2017)** and tooth decay **(Cieplik et al., 2017)**. Ondine Biomedical Inc. (www.ondinebio.com) has successfully developed photodisinfection technology for use within hospital settings, reducing healthcare-associated infections by using nasal decolonization to eradicate pathogenic microflora (*Staphylococcus aureus, Candida auris,* SARS-CoV-2, methicillin-resistant *Staphylococcus aureus*).

APPLICATIONS IN THE FOOD INDUSTRY

All microorganisms can cause food contamination, which can lead to spoilage or foodborne diseases. Decontamination practices, such as washing food with sanitizing agents or heat treating, are routinely implemented in food processing to inactivate or physically remove microorganisms from various food matrices. The reduction of microorganisms serves to extend food shelf-life and preserve nutritional quality **(Ma et al., 2017; Damyeh et al., 2020)**.

The pursuit of novel technologies for minimizing food contamination is based on the need to satisfy food safety requirements and maintain food quality without contributing to antibiotic resistance. Photodisinfection provides a promising method to safely sanitize food and surfaces without the use of harsh chemicals or antimicrobials. This technology may also reduce the consumption of water and energy compared to chemical or physical decontamination methods while reducing the cost of food processing **(Cossu et al., 2021)**.

Photodisinfection has potential to improve food sanitization at all levels of the supply chain. For food processing and packing, photodisinfection could be used as a safe and natural way to sanitize food and surfaces within manufacturing facilities. Of particular interest are meat packing facilities, as meat disinfection is currently achieved through chemical processes. Photodisinfection could provide a meat disinfection practice that preserves the quality of the food product, does not leave by-product residues from sanitizers, and does not add to antimicrobial resistance **(Cossu et al., 2021)**. In addition to improving meat processing methods, photodisinfection could be used to extend shelf life, particularly in the context of long shipping times to retailers **(Liu et al., 2016)**. This technology could also be used by retailers as a way to disinfect products as they are packaged within the retail environment. Finally, photodisinfection may also have utility within the home, as a fast and easy way to sanitize food and surfaces.

NEW PHASE OF RESEARCH

Researchers are now screening a panel of Health Canada-approved, food-safe compounds to use as photosensitizers to facilitate the use of photodisinfection in the above-mentioned areas of the food sector. An initial screen, conducted by Chinook Contract Research Inc. on behalf of Ondine Biomedical Inc., has already identified natural photosensitizers and light conditions with excellent microbicidal activity. Research is ongoing to develop this safe and effective photodisinfection technology for use within the food industry.

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This project was funded by Ondine Biomedical and the Government of Canada under the Canadian Agricultural Partnership's AgriScience Program, a federal, provincial, territorial program. This project was completed in collaboration with Chinook Contract Research.

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