Microbial decontamination using ultra-high irradiance blue light

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Objective: In addition to being pathogenic for the consumer, the presence of microorganisms on the surface of foodstuffs leads to a significant loss of food. The contamination of food occurs at the production site but also during storage when contact with contaminated surfaces. The current solution is the use of chemical molecules causing environmental and toxicological problems. In this context, it is necessary to develop microbial decontamination processes that no longer use these chemical compounds and that ensure the microbiological safety of foodstuffs. Among these processes, photodynamic microbial inactivation based on photo-oxidation, which corresponds to the excitation of exogenous photosensitisers and the production of singlet oxygen, could be used. The objective of this study was to evaluate the efficacy of ultra-high irradiance (UHI) blue light treatments targeting porphyrins, endogenous photosensitisers present in many microorganisms.

Methods: A light reactor capable of emitting blue light (LEDs at 385 and 405 nm) at UHI (901 mW/cm²) has been developed in our laboratory to apply short treatments. The effectiveness of this prototype was evaluated on vegetative and spore-forming forms of food spoilage microorganisms. Cellular damage and inactivation mechanisms were characterised by flow cytometry. Potential applications were investigated for the treatment of food contact surfaces or contaminated fruit.

Results: The application of UHI visible blue light during few minutes was able to inactivate the vegetative and spore-forming forms of the tested microorganisms. However, the treatment times required for inactivation depend on the nature of the microorganisms and their physiological state. It was also observed that 385 nm treatments were more effective than treatments at 405 nm. The lethality of the treatments could be related to the amount of singlet oxygen produced by the treatments. The plasma membrane was identified as one of the main targets whose structure is altered by these treatments. Initial trials on apples contaminated with filamentous fungi have identified scales that are potentially applicable to fruit.

Conclusion: This technology based on the use of certain wavelengths of the visible at UHI could therefore represent an innovative low-cost technology for food applications. Applications concerning the decontamination of pathogenic microorganisms could also be envisaged.