Ultraviolet Light

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Ultraviolet (UV) light is a dry and biologically inert process that decreases the microorganism count by around 99.9% with minimum heating of the packing material. Between the UV lamp and the area to be disinfected, there should be no obstruction. Since dirt absorbs radiation and thereby protects bacteria, the effectiveness of this application is therefore dependent on the sanitation of the material surfaces.

UV light | dairy industry | disinfection | UV applications | UV-C fluence

1. Introduction

Non-thermal technologies, i.e., microfiltration, UV light processing, pulsed light, high hydrostatic pressure, high-pressure homogenization, pulsed electric fields, ohmic and microwave heating, and carbon dioxide processing, have recently been implemented as an alternative to thermal treatment and have piqued public interest as a means of avoiding nutrient damage that would otherwise occur during food heat processing [1].

The Sun is the primary source of Ultraviolet light, which radiates light at several different wavelengths [2]. The alternative UV radiations can be emitted from tanning beds, mercury vapor lamps, selected halogens, fluorescents, incandescent lights, and some types of lasers [3]. Ultraviolet radiation is a non-ionizing source of invisible light that exists between visible light and X-rays in the electromagnetic spectrum (EM). UVA (315–400 nm), UVB (280–315 nm), UVC (200–280 nm), and vacuum-UV (100–200 nm) are the four major forms of UV rays produced by ultraviolet light with wavelengths between 100 and 400 nm as shown in **Figure 1** [4][5]. UV has the best germicidal effect when the wavelength is about 254 nm, which mercury vapor lamps emit [6]. The microbial deactivation can become more efficient through greater penetration of UV light which is possible with the correct UV source [2].

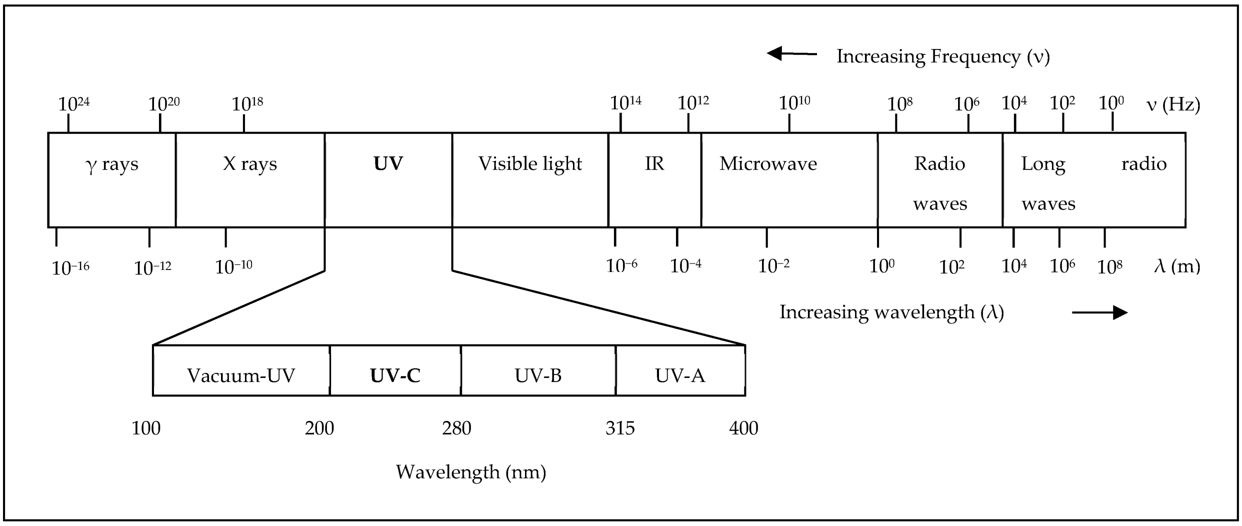

Figure 1. UV radiation and wavelengths [7][8][9].

In most UV-based disinfection systems, mercury lamps have been the source of radiation which is primarily of two types: medium pressure mercury (MPM) and low-pressure mercury (LPM) UV lamps that are reliable disinfection sources with high efficiency and low cost [2].

UV-C rays, which act as germicides, have the greatest effect on various microorganisms which include bacteria, viruses, protozoa, fungi, algae [10], and bacterial spores [4][5][11][12][13]. UVC germicidal lamps are used to sterilize air, disinfect surfaces, deter microorganisms from accumulating on food surfaces, and are a convenient and effective method to clean water without the usage of toxic chemicals [14].

In a survey study, UV radiation was identified as one of the main novel technologies currently applied or with the potential to be commercialized in 5–10 years. The respondents (food professionals from industry, academia, and government) from North America and Europe classified UV as the third and fourth cutting-edge food processing technology, respectively. The results of the survey demonstrated that the main drivers for the commercialization of novel technologies, i.e., UV treatment, were higher quality products (94%), product safety (92%), and shelf life (91%) [15].

In January 2016 [16], the EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA) delivered an opinion on UV-treated milk as a novel food submitted pursuant to Regulation (EC) No 258/97. The European Food Safety Authority (EFSA) stated that “the novel food is cow’s milk (whole, semi-skimmed or skimmed) to which treatment with ultraviolet (UV) radiation is applied after pasteurization in order to extend the shelf life of the milk and increase the vitamin D3 concentrations by conversion of 7-dehydrocholesterol to vitamin D3. The EFSA panel concluded that the novel food, UV-treated milk, is safe under the intended conditions of use as specified by the applicant.”

2. Future Technology: UV-LEDs

UV-LED lamps (UV-LEDs) are much smaller than traditional lamps, allowing them to be readily integrated into a variety of device designs [17]. UV-LEDs are being looked at as a possible competition and replacement for UV lamps. They have long been known to outperform traditional lamps, such as low pressure (LP) and medium mercury (MP) lamps, in terms of environmental friendliness and mercury-free operation [18]. UV-LEDs also emit high-intensity light immediately after being turned on; there is no warm-up time [17]. Some experiments comparing the effectiveness of UV-LED emission at various wavelengths with traditional lamps have been performed in terms of germicidal effectiveness [18].

Li et al. [19] used two UVC-LEDs emitting at 265 and 280 nm with an LP lamp (254 nm) to equate disinfection capacity and repair repression of *E. coli*. In comparison to 280 nm UVC-LED and LP lamps, the findings revealed that 265 nm UVC-LED showed the highest inactivation efficacy against *E. coli* [20].

Green et al. [21] also found that UVC-LEDs had the same degree of inactivation or higher than LP lamps (253.7 nm) for *E. coli*, *Listeria*, and *Salmonella* at an equal dosage of 7 mJ/cm^2 for 259, 268, and 275 nm wavelength. The UVC-LED wavelength of 268 nm was found to be the most powerful in the sample. As a result, it was reported that the closer the LED wavelength to 280 nm, the better the UV-LED results [20].

Furthermore, another study revealed that UV-LEDs do not contain mercury and produce steady irradiation yield irrespective of temperature, which makes them useful even at refrigerated conditions [22].

UVC generated by LEDs is a new technology that may be used to compensate for the limitations of mercury lamps. One of UV-LED technology’s main advantages is that it can be programmed to produce a certain wavelength. Whereas, UV lamps can only create a peak wavelength of 254 nm, as their inactivation ability has only been tested at that wavelength [17].

3. Conclusions

The application of UV technology can have many advantages in the dairy industry, including increased shelf life and microbial protection of dairy products, as well as energy savings due to the non-thermal technology. Nowadays, consumers look for goods that are manufactured in an environmentally friendly manner, so sustainability and environmental issues are becoming highly relevant. Ultraviolet processing can provide more desirable food items with fresh-like qualities. Many microorganisms are killed by short-wave UV-C radiation, which can be used to make food items safe. Despite the fact that UV light radiation can inactivate a broad variety of microorganisms, some elements of its usage in food should be examined. Currently, this technology is not commonly used in the dairy industry, although it may be in the future and, in order to maximize its impact on foodborne pathogens and spoilage microflora, the appropriate form of the lamp should be considered in each method. It would be of great importance to investigate the impact of this treatment on foods in terms of nutritive value as well bioavailability of nutrients.

The research showed that the MPM UV lamp is an economical and practical alternative especially for those companies that want to increase the quality of the final product. Some of the technologies are already well-established across the globe like disinfection of drinking water with UV light which is used for brewing and drug treatment. The studies in this review demonstrated the advantages of ultraviolet light, but there are some drawbacks to use it in dairy products, such as limited penetration potential, and contamination. To overcome contamination, UV Light Emitting Diodes could be of great potential instead of mercury or amalgam lamps, as these are more food plant-friendly.

Moreover, the application of UV technology in combination with other techniques, such as pasteurization, ultra-high pressure homogenization (UHPH) was reported. However, there is a need for further research in this area, in order to determine the optimal conditions for manufacturing safe products at a minimal shift in sensory and nutritive properties.

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