Light Treatments

INTERVENTION SUMMARY	
Status	Currently available
Location	Post-evisceration, during chilling and post-packaging
Intervention type	Surface exposure of carcasses, primals and products
Treatment time	10 seconds or prolonged
Regulations	UV treated water is used as a carcass rinse Approved for food contact surfaces and some brines and marinades
Effectiveness	Good where the product is exposed to the treatment Irregular shaped items may prevent uniform exposure
Likely cost	Unable to ascertain
Value for money	Likely to be good
Plant or process changes	A 10-minute treatment cabinet will take up a lot of space in a boning room, UV lamps can be retro-fitted within cold rooms and display cabinets
Environmental impact	Energy is required
OH&S	The unit would require proper shielding Exposure to UV light can cause skin cancer and damage the eyes
Advantages	Can be used on packaged product so no risk of recontamination
Disadvantages or limitations	Can induce rancidity

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Light Treatments

Ultraviolet (UV) light irradiation is commonly used in hospitals and laboratories for decontamination of surfaces, air and water. UV treatment has been used for a number of years in water purification and research is ongoing into the application of UV directly to foods. UV is an electromagnetic wave, lying outside the band of visible light. It has low penetrating power because it is a low energy wave, and its effectiveness is markedly affected by irregularities on the surface treated. As a result, it is generally limited to surface decontamination when being used to treat solid foods. UV light treatment has advantages over more traditional decontaminating treatments, such as heat treatments, in that it can be applied to raw, fresh and minimally processed foods. UV light treatments include continuous wave (CW) UV and pulsed light (PL) UV. Photosensitisation is another light technology, which may be useful for surface decontamination of food products. It involves the use of a photoactive compound. This compound is selectively taken up by the bacterial cells and can lead to cell death when exposed to visible light in the presence of oxygen (Luksiene and Zukauskas, 2009).

Ultraviolet Light

UV light causes permanent cross-links to form in the microbial DNA, preventing the cell from carrying out its normal functions (Sastry *et al.*, 2000). The lethal effect of UV light varies with intensity and length of exposure. Temperature, pH, relative humidity and degree of initial contamination also can affect its performance (Banwart, 1989). UV light has low penetrating power, because its inherent energy is low in comparison with ionising radiation, so any obstruction to the path of the rays, such as dust, shadowing or clumping of bacteria can reduce its efficacy. Therefore, UV light is less effective on a rough surface than on a smooth one (Huang and Toledo, 1982; Stermer *et al.*, 1987). The effective wavelength is between 210 and 300 nm (Banwart, 1989). Most commercial UV lamps deliver 90% of their radiation at 253.7 nm.

UV light rapidly inactivates microorganisms in culture, killing up to 4 log before the death rate slows (Shapton and Shapton, 1991). UV irradiation can be used together with other food safety treatments such as heating or hydrogen peroxide treatment, and a synergistic effect may be obtained (Tyrell, 1976; Bayliss and Waites, 1980; 1982, Sommers *et al*., 2009a, 2009b). Certain wavelengths produce ozone, which enhances the antibacterial effect (Kaess and Weidemann, 1973), but excessive ozone can cause rancidity. UV treatments have also been associated with accelerated lipid oxidation and browning due to metmyoglobin formation, particularly in pork and poultry.

In general, anaerobic organisms are more sensitive to UV light than aerobes, and Gram negative bacteria and rods are more sensitive than Gram positive and cocci (Sykes, 1965), but successes have been reported against *Salmonella* on poultry (Wallner-Pendleton *et al.*, 1994), and against *Pseudomonas aeruginosa* (Abshire and Dunton, 1981). Most studies have used low intensity UV for 9 minutes or more, but if high intensity UV light was used, exposure times could be less than 10 seconds (Stermer *et al.*, 1987). Due to poor penetrative properties, UV light is more or less limited to surface applications, but it shows promise as a post-packaging treatment. Djenane *et al*. (2001) irradiated beef steak packaged in polyethylene pouches with modified atmosphere (70% O_2, 20%

CO_2, and 10% N_2) and stored at 1°C. They found that the shelf life was extended from 12 to 28 days. The UV was applied continuously at 1000 lux in a retail display cabinet. Under a standard fluorescent tube light, colour and odour deteriorated rapidly from day 6, whereas with the UV lamp, deterioration only became noticeable after day 17, and was still scored as “slight” at day 28. Microbial counts from day 22 were 2 log lower in the UV-exposed packs than in the standard fluorescent light-exposed packs.

Sommers *et al*. (2009b) demonstrated that UV in combination with potassium lactate and sodium diacetate reduced the numbers of *L. monocytogenes* inoculated onto the surface of ready to eat frankfurters by up to 1.9 log.

Cool room UV units and UV water treatment systems can be obtained from Australian Ultra Violet Services Pty Ltd and Ultra Violet Products (Aust) Pty Ltd. From overseas, Safe Foods Corporation markets a UV system under the Fresh*Light* brand for use in liquids including brines and marinades, and Aquuionics or Hanovia supply air and water treatment systems.

Pulsed Light

Pulsed UV light consists of the application of short flashes of an intense broadband spectrum (100-1100 nm), which is rich in the UV range, and is considered to be more effective and safe than conventional UV treatments (Keklik and Demirci, 2014). Microbial inactivation is thought to be a multi-target process (Gómez-López *et al*., 2007). Apart from the changes in DNA, which occur in conventional UV treatment, physical damage to cell membranes and other structures can also occur. Pulsed UV-light has been used to inactivate *E. coli* O157:H7 and *L. monocytogenes* on salmon fillets (Ozer and Demirci, 2006). An approximate 1-log reduction was achieved after a treatment time of 60 seconds at 8 cm distance from the surface, with no detrimental effect to the product quality. The researchers used a laboratory-scale unit available from Xenon Corporation, distributed in Australia by Warsash Scientific Pty Ltd.

Paskeviciute *et al*. (2010) demonstrated that *S.* Typhimurium and *L. monocytogenes* levels on the surface of chicken could be reduced by 2-2.4 log cfu/mL by treatment with a combination of pulsed light and UV for 200 seconds. Ganan *et al*. (2013) reported a 1.5-1.8 log reduction of *L. monocytogenes* and *S.* Typhimurium on ready-to-eat cured meat products, following an 11.9 J/cm^2 pulsed light treatment.

The US FDA has approved the use of pulsed UV light to treat food under the following conditions: the radiation source consists of a Xenon flash lamp designed to emit broadband radiation in the range of 200 to 1,100 nm with a pulse duration not greater than 2 ms; the treatment is used for the control of microorganism on the surface; foods treated shall receive the minimum treatment required to accomplish the intended effect; and the total cumulative dose shall not exceed 12.0 J/cm^2 (FDA 2011). Limitations of this technology include possible discolouration of the meat due to high heat at the surface of the product, non-uniform treatment of the product due to an uneven surface and OH&S issues.

The use of light emitting diodes (LEDs) has shown some promises as a means of inactivating pathogenic bacteria (Maclean *et al*., 2009). When a bacterial culture was exposed to a 405 nm LED array, Gram-positive bacterial numbers were reduced by 5 log cfu/mL after 60-90 minutes. Gram-negative bacteria, such as *E. coli*, required longer exposure time of up to 300 minutes for a 3-log reduction.

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