

LUMENASAFE ANTIBACTERIAL LIGHTING FACTS

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1. BACKGROUND – WHY LUMENASAFE IS NEEDED?

a. FOODSAFETY IS A HUGE GLOBAL PROBLEM

i. Globally

According to [World Health Organization \(WHO\)](#), access to sufficient amounts of safe and nutritious food is key to sustaining life and promoting good health. Unsafe food containing harmful bacteria, viruses, parasites or chemical substances, causes more than 200 diseases – ranging from diarrhea to cancers.

Problem impact globally:

- 33 million healthy years lost every year
- 600 million people fall ill and 420 000 of them die
- 550 million diarrheal diseases (230 000)
- 240 million under 5-year-old children (125 000)

ii. In Finland

Although the general hygiene and food industrial process in farming, food product manufacturing, logistics and sales are in high level, foodborne illnesses are a fact also in Europe. In 2014–2016 [Finnish Food Authority](#) registered in total of 132 foodborne outbreaks in Finland. The total reported number of people infected was 2 761. 32 % of these were cases of norovirus from restaurants, and typically the food vector was vegetables or vegetable products. Secondly, common food vector was meat and meat products. Typical route causes for

the contamination resulted from problems with the cold chain, too long storage period, or inadequate hand hygiene.

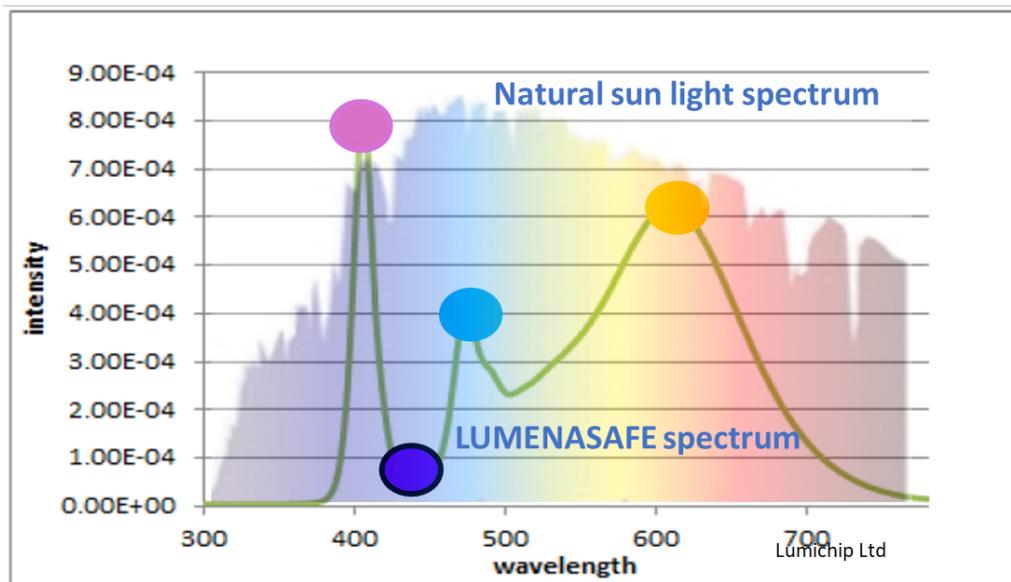
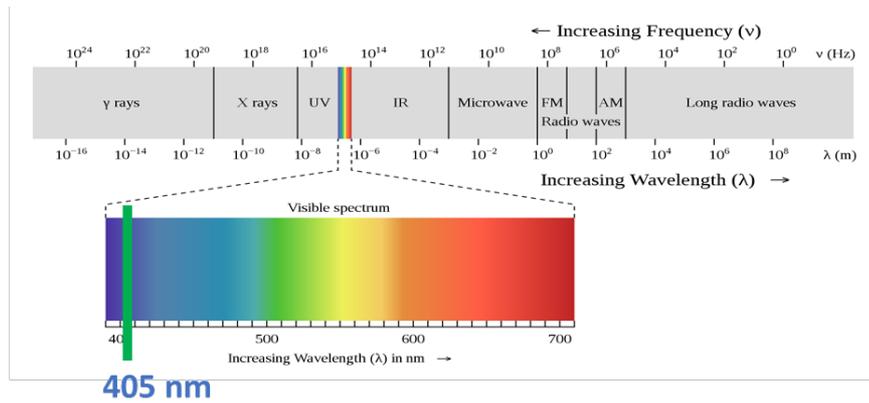
More information in TABLE I, typical food pathogens.

Elsewhere in the media (in Finnish): <https://www.hs.fi/kaupunki/art-2000006543845.html>

2. LUMENASAFE – HOW DOES IT WORK?

LUMENASAFE is based on the ability of visible violet-blue light to reduce bacteria and other harmful organisms in the surface of food. The disinfection property is based on the use of 405 nm peak in existing in the natural visible sun light spectrum. Compared to UV disinfection LUMENASAFE can be used also when human are present. The antibacterial effect of 405 ± 5 nm LED illumination on bacteria and other pathogens is due to physical damage to bacterial membrane (Kim 2015).

The energy of the visible blue light together with oxygen in air, causes a photodynamic inactivation reaction in the bacteria. In the bacteria there naturally exists porphyrin compounds which acts as photosensitizer. When a photosensitizer is in its excited state, it can interact with oxygen and produce radicals and reactive oxygen species. They can interact with cellular components including unsaturated lipids, amino acid residues and nucleic acids. If sufficient oxidative damage ensues, this will result in bacterial cell death.



a. VISUAL LIGHT DISINFECTION, VLD, IS A PROVEN TECHNOLOGY IN FOODSAFETY

The antibacterial properties of visible blue light and its's feasibility in food safety have been under active research in few recent years. The research has been focusing on following research questions:

1. To understand better the killing mechanism of a bacteria and other pathogens
- 2) To learn the sterilization performance on various bacteria and other pathogens
- 3) To learn the sterilization performance on various food products
- 4) To learn the required energy dose for achieving practical sterilization performance and finally
- 5) to correlate what illumination intensity of blue light is adequate.

Good summaries on the research related to food safety can be found in Katri Ojala's [Master's Thesis](#) from 2019 (In Finnish).

A more broader state-of-art review on antimicrobial blue light inactivation of pathogenic microbes have been written by [Wang et al](#) from 2017 and by [Maclean et al](#) from 2014, covering various other applications such as hospital disinfection, dental hygiene, animal infections and plant diseases.

b. EXAMPLES OF RESEARCH DONE ON ANTIMICROBIAL EFFECT

Some examples of research done on the antimicrobial effect of blue light on the spoilage microbes and on the microbiological safety of food have been presented in TABLE I

Research set-up	Foodstuff	Micro-organism	Main findings	Source
Blue Light (405 nm) antibacterial impact on cooked chicken against 3 different Salmonella bacteria at 4, 10 and 20 °C	Cooked chicken	<i>Salmonella enterica</i>	Bacterial concentration reduced on the surface of the chicken	Kim et al 2017
Blue Light (405 nm) antibacterial impact on fresh salmon at 4 and 12 °C	Fresh salmon	<i>Listeria monocytogenes</i> , <i>Salmonella enterica</i>	LED-illuminated bacterial population was significantly reduced	Li et al 2018
Blue Light (405 nm) antibacterial impact on melon at 4 and 20 °C	Cantaloupe melon rind	<i>Listeria monocytogenes</i> , <i>Salmonella spp</i>	Proven inactivation capability on listeriosis and salmonellosis	Josewin et al 2018
Blue Light (405 nm) antibacterial impact on flesh papaya at 4, 10 and 20 °C	Fresh papaya	<i>Salmonella enterica</i>	LED-illuminated bacterial population was significantly reduced	Kim et al 2017

c. VISUAL LIGHT DISINFECTION, VLD, IS SAFE FOR HUMANS

The use of a wavelength 405nm for continuous disinfection of harmful bacteria has been verified for being safe for humans according by international Photobiological Safety Standard (IEC62471) of International Electrotechnical Commission.

http://www.lginnotek.com/en/itk_news/lg-innotek-introduces-visible-disinfection-lighting-solution/

<https://indigo-clean.com/safety>

d. VISUAL LIGHT DISINFECTION, VLD VS. OTHER TECHNOLOGIES

Traditional food storage methods like refrigeration can typically slow down the microbial growth, but they cannot kill them. Other additional processing, like heating, can change the food sensory properties and nutrition quality. Ultraviolet light and gamma radiation have significant safety hazards associated with human

exposure and can cause DNA mutations and erythema. This means that the room need to be vacated during the use.

TABLE II LUMENASAFE compared to other methods

	LUMENASAFE	Ultra Violet -C	High Pressure processing	Heat treatment	Preservatives	Refrigeration
Safe for humans in same room	✓	✗	✓	✓	✓	✓
No change in food properties: taste, nutrition value...	✓	?	✗	✗	✗	✓
No additional food processing	✓	✓	✗	✗	✗	✓
Disinfective	✓	✓	✗	✗	✗	✗

SOURCES:

World Health Organization (WHO), Food safety – key facts, <https://www.who.int/news-room/fact-sheets/detail/food-safety>

Ruokavirasto, Elintarvike- ja vesivälitteiset epidemiat Suomessa vuosina 2014–2016, https://www.ruokavirasto.fi/globalassets/tietoa-meista/julkaisut/julkaisusarjat/julkaisuja/ruokaviraston_julkaisuja_2_2019_elintarvike_ja_vesivalitteiset_epidemiat.pdf