Pulsed light processing

Pulsed light for microbial inactivation

Identification

Key words  pulsed light, UV, non-thermal technology, decontamination, inactivation, microorganisms, bacteria, moulds, yeasts, viruses, spores

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How does it work?

Primary objective  Non-thermal microbial inactivation of food products, food related packaging and food processing equipments.

Working principle  Pulsed light (PL) technology involves the use of intense and short duration light pulses. The spectrum of the light pulses is broad, ranging from ultraviolet (UV, 100 nm) to near infrared (nIR 1100 nm), with a considerable amount of light in the short-wave UV domain. To produce the light pulses, electromagnetic energy is accumulated in a capacitor during fractions of a second and then released in the form of light within a short time (ns to ms). The resulting effect consists in an amplification of power with a minimum of energy consumption.

Light pulses used for food processing applications typically emit 1 to 20 flashes per second at an energy density in the range of about 0.01 to 50 J/cm² at the treated surface. Although the light spectrum generated by the PL technology has a similar composition to sunlight, the disinfection effects arise because the intensity involved is roughly 20,000 to 90,000 higher than that of sunlight at earth’s surface. In comparison with the continuous UV light disinfection systems, the PL technology shows considerable advantages:

• has a higher penetration depth and emission power
• is more effective and rapid in microorganism inactivation (the delivered energy is multiplied manifold)
• produces a lower heating (due to short pulse duration and cooling period between pulses)

The mechanism of action of the PL processing is very complex including short-term, thin-layer temperature effects – phototermic effects (the treated surfaces briefly reaching 300-7000°C), photochemical effects (formation of free radicals) and DNA damage to micro-organisms [1, 2] With PL processing there is a reduction of the spoilage of treated products by inactivation of moulds, yeasts, fungi, viruses and bacteria (Salmonella, Typhimurium, Listeria, Pseudomonason, Campylobacter, E.coli, etc.)
The PL technology was reported [1-3] to show additional positive effects such as:
- enhancement of food quality by increasing food’s natural (i.e., by boosting the Vitamin D content)
- obtaining products with high levels of organoleptic and nutritional quality but free of health risks
- decrease of the allergenic properties of some foods (peanuts and peanut related products)

In some cases, heating of food products accompanying the PL process, can induce the negative effects specific to thermal processing. The most important technological problem related to the use of PL technology consists in finding ways to control (to avoid) food heating and to treat foods homogeneously.

**Important process parameters**
- light pulse intensity, pulse number and duration, light spectral composition, light source positioning, distance to the sample

**Important product parameters**
- absorption/transmission of the treated product, surface topography, penetration depth, opacity, transparency of food product and package

### What can it be used for?

**Products**
- Liquid foods (cold pasteurization of liquid food such as milk, juices) and solid foods (fruits, vegetables, eggs, shell, fish and meat) to be disinfected

**Operations**
- Disinfection and preservation of food products.

**Solutions for short comings**
- Rapid and energy saving decontamination of the food products and food related packaging and equipments
- Replacement of the traditional thermal and chemical disinfection technologies

### What can it NOT be used for?

**Products**
- For opal products the PL technology is only a surface treating method. To keep the appropriate level of efficiency of the PL technology, a uniform treatment of the target surface is required. Restricted products are:
  - Light sensitive products (oxidation may occur)
  - High protein or oil content foods (an important amount of the radiation can be absorbed by proteins and oils reducing the effective dose available for microbial inactivation)
  - Carbohydrate and water content of food products has variable effects on microbial destruction of the PL treatment depending on the type of microorganisms
  - Colored food powders (i.e., black pepper, wheat flour), since the thermal effect of PL dominates the UV effect, visual and flavor qualities of food powders suffer undesirable alteration before microbial inactivation is reached
  - Foods with rough or uneven surfaces, crevices, or pores (microorganisms show the ability to harbor in small openings)
  - Seeds (cereals, grains, and spices), due to their opacity with respect to the spectral range used in PL technology

**Operations**
- The PL technology is a non-thermal technology. However, heating may occur accidentally during the use of PL technology. In order to avoid this effect, the following recommendations are desirable:
  - use of a limited number of pulses [3-4]
  - use of lower duration pulses
  - an appropriate cooling period between pulses
  - a low IR content of the spectrum for the pulses
  - cooling of light sources

**Other limitations**
- Uniformity of the treatment is limited by the product geometry and opacity.
Risks or hazards

PL technology is considered free of any health risks. However, more research is needed on the nutritional consequences and on the applicability of photosensitization to foods. PL is safe to apply but some precautions have to be taken to avoid exposure of workers to light and to evacuate the ozone generated by the shorter UV wavelengths. More research is needed on the nutritional consequences of applicability of photosensitization to foods and possible formation of toxic by-products.

Implementation

Maturity

This technology is available at industrial scale. Laboratory studies demonstrated that PL disinfection technology is clearly efficient, but its efficacy on real foods is still under investigation. Further studies are necessary in order to:

- elucidate the microbial inactivation mechanisms
- elucidate the effects of PL treatments on food properties beyond safety and spoilage
- to optimize the experimental parameters to achieve the target inactivation level for specific food applications without affecting quality
- design PL equipments with good penetration and short treatment times needed for technological and commercial purposes

Modularity/Implementation

PL processing can be incorporated easily into in-line manufacturing processes. Due to its flexible design and scalability, PL could become a relatively inexpensive solution for small- or medium-size companies.

Consumer aspects

PL processing corresponds to the increased consumer awareness about minimally processed foods [7, 9].

Legal aspects

PL treatment was approved for food surface decontamination by the US Food and Drug Administration (FDA) in 1996. The approved procedure uses light pulses of wavelengths between 200-1000 nm, with a pulse width not exceeding 2 ms and the cumulative level of the treatment not exceeding 12 J/cm² (FDA Code 21CFR179.41).

The legal status of PL technology in the European Union has a different approach, since the legislation is not technology oriented but food and food ingredient oriented. The PL technology fall in the scope of Regulation (EC) 258/97 on novel foods and novel food ingredients, article 1, item f (European Union, 1997). Among other categories, this legislation applies to foods and food ingredients to which a production process not currently used has been applied, and evaluates possible changes in nutritional value, metabolism and level of undesirable substances.

Environmental aspects

PL processing is an energy-saving, waste-free, environmentally friendly technology.

Facilities that might be interesting for you

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<tr>
<th>Title</th>
<th>Institute/company</th>
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<tr>
<td>Lab scale oven for infrared and impingement heating - SP</td>
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<td>Pilot scale tunnel oven for infrared and impingement heating - SP</td>
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<td>Pulsed light labscale IRTA</td>
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<td>UV irradiation - FRIP</td>
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Further Information

Institutes
IRTA

Companies
Claranor, Steribeam

References
5. P.N.Haughton, J.G.Lyng, D.J.Morgan, D.A.Cronin, S.Fanning, P.Whyte, Foodborne Pathogens and Disease, Efficacy of high-intensity pulsed light for the microbiological decontamination of chicken, associated packaging, and contact surfaces, doi/abs/10.1089/fpd.2010.06-40.

Source: