Infrared heating

Identification

Key words  infrared radiation, IR, infrared heating, drying, roasting, blanching, dehydration, infrared emitter, pasteurisation, surface pasteurisation, baking

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How does it work?

Primary objective  Infrared (IR) heating of foods involves applications such as thermal processing, microbial decontamination, roasting, drying and baking. The use of IR heating in food applications will reduce the processing time and energy loss and extend shelf life of the food product.

Working principle  Infrared (IR) radiation is a part of the electromagnetic spectrum with wavelengths between 0.74 µm and 1 mm i.e. wavelengths between ultraviolet and microwave energy. The IR radiation can be divided into three different categories: near (NIR; 0.75-1.4 µm), medium (MIR; 1.4-3 µm) and far IR (FIR; 3-1000 µm). In general, near-IR is the most used wavelength for industrial heating applications because of the higher temperatures produced [2] but FIR radiation could be advantageous for food processing because most food components absorb energy in the FIR region [1].

IR light penetrates food and causes changes in the vibration and rotation of molecules. When the molecule returns into the normal state, the absorbed energy is transferred into heat. In food products, water is the molecule most affected by IR radiation. Other molecules affected by IR are proteins, lipids and carbohydrates containing polar groups (-NH, -CO, -OH, C=C) [2].

IR radiation has advantages compared with conventional heating techniques such as direct and fast heat transfer, no heating of the surrounding air and the power level and penetration depth can easily be adjusted.

IR heating has been applied in drying, baking, roasting, blanching, pasteurisation, and sterilisation of food products and efficient practical use can be achieved by combining IR heating with microwave or other common conductive and convective modes of heating e.g. during the baking, drying processes and roasting [1-6].

The effect of IR treatment on nutritional quality has been evaluated for different food products, with varying results. For many food products the IR heating process can be designed to avoid alteration of quality characteristics such as vitamins, proteins and antioxidant activity [1].

Additional effects

- Reduced processing time and energy loss
- Uniform temperature in the product
- High heat fluxes
- High degree of process control
- Surface colour development
- Decreased flavour loss

Images
### Important process parameters

**General parameters:**
IR emission, IR power, temperature control, processing time, IR wavelength (shorter wavelengths give greater penetration depth and surface temperature) [1, 2].

**Parameters related with operations:**
- Microbial inactivation: IR power, temperature of the food sample, sample depth, types of organisms (spores are more resistant than vegetative cells), moisture content and the physiological phase of the microorganism (exponential cells are more sensitive than stationary phase cells) [1].
- Drying: surface temperature of the radiator, air temperature, air velocity, infrared power [1].
- Roasting: water activity, IR intensity, temperature control, IR absorption [3,4].

### Important product parameters

**General parameters:**
Thickness of the product [2], moisture content (absorption increases with decreased moisture content), water activity (IR penetration depth is expected to decrease with increased water activity) [2], temperature of the food sample, food composition [2].

### What can it be used for?

<table>
<thead>
<tr>
<th>Products</th>
<th>Fruits, vegetables, fish, pasta, rice (drying)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operations</td>
<td>Pizza, bread, biscuit (baking or surface pasteurisation of bread)</td>
</tr>
<tr>
<td></td>
<td>Coffee, cacao, cereals, nuts (roasting, pasteurisation, sterilisation)</td>
</tr>
<tr>
<td>Solutions for short comings</td>
<td>IR heating gives great energy efficiency, heat transfer rate and heat flux that result in time-saving as well as increased production line speed. Attractive technique for surface heating applications.</td>
</tr>
</tbody>
</table>

### What can it NOT be used for?

<table>
<thead>
<tr>
<th>Products</th>
<th>IR heating is mainly efficient for solid products.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operations</td>
<td>IR heating is attractive primarily for surface heating applications but could be successfully combined with conventional techniques to be able to meet special requirements, for example to speed up the surface colour formation during baking of bread.</td>
</tr>
<tr>
<td>Other limitations</td>
<td>Low penetration power.</td>
</tr>
<tr>
<td>Risks or hazards</td>
<td>The risks of infrared energy for humans are related to hazards for the eyes and also skin hazards due to heating/drying of tissue.</td>
</tr>
</tbody>
</table>

### Implementation

**Maturity**
Several applications are already running in industry. These are mainly surface pasteurisation of for example nuts, but also in combination with other technologies for baking. Possible equipment already exists and two different methods are used in practical applications, either electrical or gas emitters [2]. Appropriate processing parameters for different food processes need to be tested. Future research may include detailed understanding into how IR interacts with food components and how IR affects changes in taste and flavour.

**Modularity/Implementation**
IR heaters can be installed in the existing production line.
**Consumer aspects**

IR heating has been used in the restaurant business for the last 25 years. However, consumers may be sceptic towards IR heating, as it sometimes is assumed to be the same as irradiation of foods, which may be regarded as negative due to assumed health effects [8, 9].

**Legal aspects**

The NIR and MIR techniques adhere to stringent European Union food authenticity legislation.

**Environmental aspects**

Energy efficient, short processing time.

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**Facilities that might be interesting for you**

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