LED lighting in vertical farming systems enhances bioactive compounds and productivity of vegetables crops

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1. Introduction

**LEDs opens opportunities for vertical farming**

- Full control of production process
- Limited area
- Anywhere
- Independent of environment
- Sustainably, but high electrical consumption
- Guarantee on quantity and quality
- 2-3 times higher costs
1. Introduction

Advantages of vertical farming

- Optimize nutrients and water consumption
- Hygiene = no pesticides needed
- Very little nutrients use
- Short chains production
- Products with added value: guarantees, quality, healthy, special product, marketing concept (e.g. local (Km 0), hygienic, etc)
- Less food waste
- Circular economy (reuse of outputs)
2. Materials and Methods

- Data from the 2013-2022 period
- Smart tools and Boolean: AND, OR, and NOT
- Proximity: PRE/and W/
  - key- or co-words: ‘Vertical farming’ AND led

Data of interest of each article:
- Plant species
- The main goal
- Geographic location
- Nutritional parameters
- Spectra, light intensity and photoperiod
- Conclusions

Bibliometric map
- keyword co-occurrence ratio
- Clustering algorithm of the VOSviewer®

Scopus

64 articles and 476 keywords

47 articles was extracted that analyzed effects bioactive compound and 2018-2022 period

‘Article title, Abstract, and Keywords’

Article title, Abstract, and Keywords’
3. Results

3.1. Crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>% used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lettuce</td>
<td>37</td>
</tr>
<tr>
<td>Spinach</td>
<td></td>
</tr>
<tr>
<td>Chicory</td>
<td>22</td>
</tr>
<tr>
<td>Mizuna</td>
<td></td>
</tr>
<tr>
<td>Chinese Kale</td>
<td>19</td>
</tr>
<tr>
<td>Coriander</td>
<td></td>
</tr>
<tr>
<td>Watermelon</td>
<td></td>
</tr>
<tr>
<td>Watercress</td>
<td></td>
</tr>
<tr>
<td>Canola</td>
<td>16</td>
</tr>
<tr>
<td>Marjoram</td>
<td></td>
</tr>
<tr>
<td>Basil</td>
<td></td>
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<tr>
<td>Kalanchoe</td>
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<tr>
<td>Cucumber</td>
<td></td>
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<td>Rockt</td>
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<tr>
<td>Peper</td>
<td>6</td>
</tr>
<tr>
<td>Broccoli</td>
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<tr>
<td>Tomato</td>
<td></td>
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<tr>
<td>Pumpkin</td>
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<tr>
<td>Strawberry</td>
<td></td>
</tr>
<tr>
<td>Pepper</td>
<td></td>
</tr>
<tr>
<td>Spinach</td>
<td></td>
</tr>
</tbody>
</table>
3. Results

3.2. Clustering

Figure 1. Bibliometric map generated from an analysis of the most repeated keywords in articles published during period 2013-2021. Different colours represent the diversity of thematic clusters found and the associated keywords: Red (cluster 1), green (cluster 2) and blue (cluster 3).

Figure 2. Global distribution of the main countries in which researchers have used the vertical farming and bioactive compounds in vegetables crops studies.

China, South Korea and Japan \{ 60\% \}
3. Results

3.3. Nutritional Parameters

Nitrate is highly correlated with chlorophyll content in plants.

Cancerogenic nitrosamines

75% of the nitrates consumed are supplied by vegetables

Two hypotheses
- Sugar availability
- Direct light effect
  - Electron transport
  - Light signalling: biosynthesis pathway

Figure 3. Research topics in the vertical farming on nutritional parameters. Values are expressed as percentages (n = 100)

Marcelis et al., 2012
3. Results

3.4. Light and Spectral Parameters

Figure 4. Type of spectra and color (A) used in the analyzed research. Data are expressed as percentage (n = 118). B (Blue 450-495 nm); R (Red 620-700 nm); FR (Far-red 700-800 nm); G (Green 500-560 nm); O (Orange 600-630); UV (380-450).
3. Results

3.4. Light and Spectral Parameters

Figure 4. Light intensity (μmol m⁻² s⁻¹) (B) used in the analyzed research. Data are expressed as percentage (n = 118). B (Blue 450-495 nm); R (Red 620-700 nm); FR (Far-red 700-800 nm); G (Green 500-560 nm); O (Orange 600-630); UV (380-450).
The use of specific spectra fitting within the ranges of maximum photosynthetic efficiency significantly enhances the nutraceutical quality of a wide range of vegetables species.

The recommended intensity light for vegetables crops is in the range of 150 and 200 µmol m\(^{-2}\) s\(^{-1}\).

The combined effect of LED lighting through vertical farming systems is an alternative to increase the nutritional parameters and productivity of vegetables crops and optimising the raw resources use, such as water and energy.
Thank you for your attention

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