BIOFORTIFICATION OF SWISS CHARD BABY LEAFY GREENS WITH SELENIUM AND IODINE IN INDOOR VERTICAL FARMING SYSTEMS

Alexis Pereira,[1,2,3] Maria Inês Dias,[1,2] M. Beatriz P. P. Oliveira,[3] José Pinela[1,2]

[1]Centro de Investigação de Montanha (CIMO), Instituto Politécnico de Bragança, Portugal

[2]Laboratório Associado para a Sustentabilidade e Tecnologia em Regiões de Montanha (SusTEC), Instituto Politécnico de Bragança, Portugal

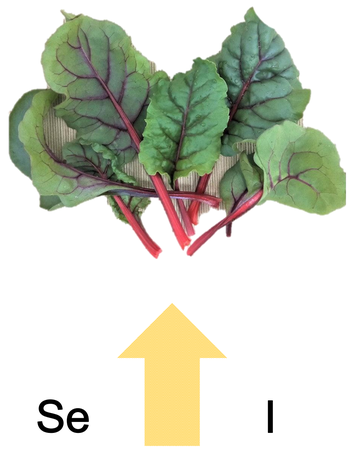
[3]REQUIMTE/LAQV, Departamento de Ciências Químicas, Faculdade de Farmácia, Universidade do Porto, Portugal

*jpinela@ipb.pt

Introduction

Agrifood systems are currently facing scrutiny due to their capacity to address the challenges posed by population growth, climate change, and depletion of natural resources. Consequently, addressing food insecurity and malnutrition has become a significant focus of the UN's 2030 Agenda for Sustainable Development. One critical aspect of human nutrition is the deficiency of essential micronutrients like selenium and iodine (the so-called hidden hunger), which affects billion people worldwide and leads to severe health issues [1]. Climate change can further exacerbate this problem by reducing the levels of these elements in the soils and, consequently, in food crops [2].

Swiss chard (*Beta vulgaris* subsp. *cicla*) is an herbaceous leafy vegetable consumed worldwide and popular for its year-round availability and affordability. It is rich in antioxidants and the leaves and stalks contain high quantities of chlorophyll and betalain pigments, dietary fiber, and micronutrients such as vitamins A and C and minerals such as calcium, iron, and phosphorus [3].

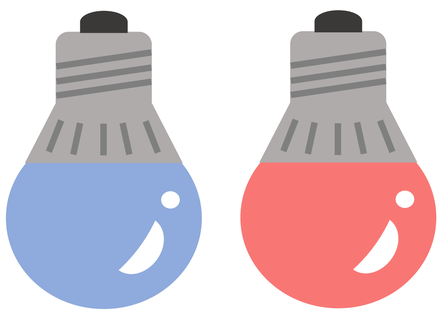


- Selenium (Se) is a constituent of proteins with critical biological functions. Its recommended daily intake is 55 µg. The biofortification of vegetables is based in the addition of organic ($C_3H_7NO_2Se$, $C_5H_{11}NO_2Se$) or inorganic (SeO_2, Na_2SeO_3, Na_2SeO_4) compounds [4];
- Iodine (I) is a mineral element obtained only through food, which aids in the production of thyroid hormones (thyroxine and triiodothyronine), creating proteins and enzyme activity, as well as regulating normal metabolism. Its recommended daily intake for adults is 150 µg. The biofortification of vegetables is based in the addition of inorganic compounds (I^-, IO_3^-) [5].

Objective

Develop sustainable methods for Swiss chard (*Beta vulgaris* var. cicla) baby leafy greens biofortification with selenium and iodine under vertical farming systems.

Methodology



LED 447 nm - 660 nm wavelengths

+

Hoagland's nutrient solution

+

Different concentrations of Se and I

- Morphophysiological parameters
  - ❑Fresh weight
  - ❑Yield
  - ❑Plant height
  - ❑Leaf area
- Nutritional composition
  - ❑Fat
  - ❑Ash
  - ❑Protein
  - ❑Fibre
  - ❑Carbohydrates
  - ❑Energy
- Chemical composition
  - ❑Free sugars
  - ❑Fatty acids
  - ❑Phenolic compounds
  - ❑Tocopherols
  - ❑Organic acids
  - ❑Photosynthetic pigments
  - ❑Mineral elements
  - ❑Free and conjugated amino acids
- Bioavailability and Bioaccessibility
  - ❑Simulated gastrointestinal digestion with CaCo-2 cells
- Antioxidant activity
  - ❑Thiobarbituric acid reactive substances formation inhibition
  - ❑Oxidative hemolysis inhibition
  - ❑Cellular antioxidant activity

Future perspectives

This transdisciplinary research is expected to provide sustainable production techniques to improve nutritional status of Swiss chard baby leafy greens through biofortification in controlled-environment vertical farms. The anticipated outcomes have the potential to catalyse the development of innovative food production processes, ultimately leading to the creation of more sustainable, healthier, and nutrient-rich plant foods, creating an impact in the scientific and socio-economic fields.

References

[1] G. Genchi, G. Lauria, A. Catalano, et al., Int. J. Mol. Sci., 24 (2023) 2633.
[2] V. L. Nascimento, B. C. O. Q. Souza, G. Lopes, et al., Front. Plant Sci., 13 (2022) 836835.
[3] T. Casey Barickman, Dean A. Kopsell, Sci. Hortic., 204 (2016) 99-105.
[4] Office of Dietary Supplements - Selenium. (n.d.). https://ods.od.nih.gov/factsheets/Selenium-HealthProfessional/ (accessed October 2023).
[5] Office of Dietary Supplements - Iodine. (n.d.). https://ods.od.nih.gov/factsheets/Iodine-Consumer/ (accessed October 2023).

Acknowledgements

The authors are grateful to the Foundation for Science and Technology (FCT, Portugal) for financial support through national funds FCT/MCTES (PIDDAC) to CIMO (UIDB/00690/2020 and UIDP/00690/2020) and SusTEC (LA/P/0007/2020). National funding by FCT, through the scientific employment program-contract with M.I. Dias (CEEC Inst) and J. Pinela (CEECIND/01011/2018) and the individual research grant (2023.00954.BD) of A. Pereira.