Using vertical farming systems for adapting nutritional content of crops

Annika Bucky[1*], Martina Pičmanová[2], Victoria Porley[3], Simon Pont[2], Alexandra Johnstone[1], Derek Stewart[2]

[1]The Rowett Institute, University of Aberdeen, Aberdeen, AB25 2ZD, United Kingdom

[2]The James Hutton Institute, Invergowrie, Dundee, DD2 5DA, United Kingdom

[3]Intelligent Growth Solutions, Invergowrie, Dundee, United Kingdom

*Contact e-mail: a.bucky.22@abdn.ac.uk

Have a look inside a vertical farm and learn more about our research

Introduction

- With population growth and rising shortages of farmland for local urban food supplies**, vertical farming has the potential to support local food production and security** (1)

- The growing system footprint is reduced by growing in three dimensions and as a result allowing **the opportunity of urban food production using derelict and/or poorly used land** (2)

- Vertical farming as a Total Controlled Environment Agriculture (TCEA) system provides **new opportunities for tailoring crops to achieve sufficient nutrient supply on a population level**

The aim of this study was to **investigate the nutritional quality of produce grown in a vertical farming system and..**

1 …the suitability of different crop types for biofortification with zinc and iron

WHY?

Micronutrient intakes, including iron and zinc, are **below the recommended daily intake** in the UK (3)

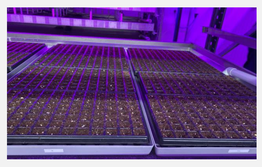
Both iron and zinc play **critical roles in human nutrition** (4)

HOW?

Kale Babyleaf (*Brassica oleracea*)

Kale Microgreens (*Brassica oleracea*)

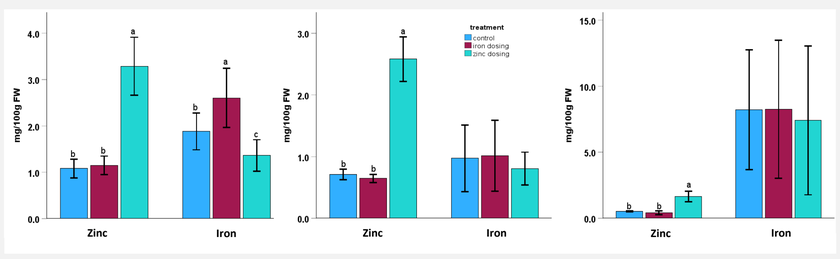
Pea microgreens (*Pisum sativum*)



3 conditions:
(1) **control** (standard nutrient solution)
(2) **Zn dosing** (+20 mg L^{-1} zinc in the nutrient solution)
(3) **Fe dosing**(+20 mg L^{-1} iron in the nutrient solution)

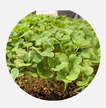
Mineral concentrations

Zinc and iron levels in 100g fresh plant material under 3 treatments



➢205% increase in zinc levels
➢38% increase in iron levels

➢264% increase in zinc levels



➢217% increase in zinc levels

Zinc or iron reference nutrient intake covered by 30g of fresh plant material from zinc or iron.

Crop	Fe-treated % RNI of Fe		Zn-treated % RNI of Zn	
	Men	Women	Men	Women
Pea microgreens	9	5	10	14
Kale microgreens	28	17	5	7
Kale babyleaf	4	2	8	11

2… the effects of different red-to-blue ratios (R:B) of the LED light spectrum

WHY?

Controlled lighting systems can be utilized to **influence plant growth rates, yield and composition** including **important nutrients and health-beneficial phytochemicals** (5)

HOW?

Micro Amaranth Red Aztec (*Amaranthus tricolor* L.)

Red Batavia Lettuce (*Lactuca sativa* L.)

The consumption of **plant foods high in antioxidants** (rather than isolated supplements) **is associated with a lower risk of chronic oxidative stress and the related symptoms** (6)

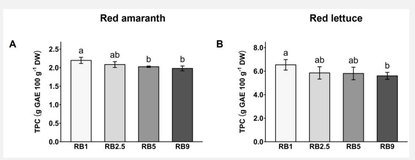
Grown under 4 different light recipes:

Treatment	R:B ratio	Spectrum (Percentage intensity) Blue (%)	Green (%)	Red (%)	Far red (%)	PPFD (µmol m^{-2} s^{-1})
RB1	1	44	5	44	7	253
RB2.5	2.55	25	5	64	7	255
RB5	5	15	5	74	7	255
RB9	9	9	5	80	7	254

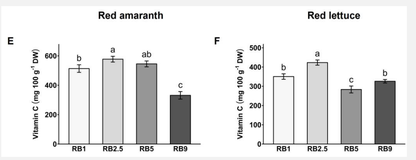
Biometrics and antioxidant components & antioxidant capacity

A higher proportion of red light **affected growth** with increased stem height

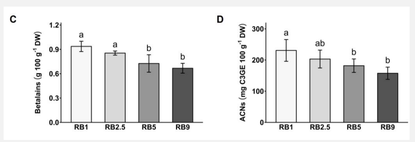
The increase of the blue light fraction resulted in the **upregulation of antioxidative components and antioxidant capacity**



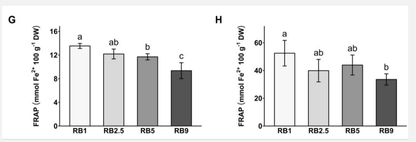
Polyphenols



Vitamin C



Betalains and anthocyanins



Antioxidant capacity

Conclusions

- The crops investigated in the study were **suitable for biofortification with zinc, while only the pea microgreens were suitable for both zinc and iron biofortification.**

- **The zinc dosed crops could cover up to 14% of the recommended nutrient intake (RNI) for zinc.**
- **The iron dosed crops could even cover up to 28% of the iron RNI**

- It is possible to **increase zinc concentrations while simultaneously increasing health benefitting components** e.g. glucosinolates in Brassicaceae species**.**

- Light ratios had a **significant influence on the growth** of red amaranth and red lettuce as well as on the **accumulation of plant secondary metabolites**

- Our findings demonstrate that it is possible to use LED lights in a vertical farm setting to **modulate, possibly enhance, the phenotypic properties and/or nutritional quality of crops**, using different ratios of red and blue light.

- Overall, **light recipes can be individually tailored** according to the type of crop as well as the desired outcomes

To determine the effects on human health of plants grown in vertical farms, human studies need to be conducted in which the effects of differently grown produce can be observed and analysed.

References
(1) Van Gerrewey et al. (2022) Agronomy, 12(2)
(2) SharathKumar M, Heuvelink E, Marcelis LFM (2020) Trends Plant Sci., 25(8)
(3) Derbyshire E (2018) Front Nutr., 19(5):55
(4) Coad J, Pedley K (2014) Scand J Clin Lab Investig Suppl., 244:82–9
(5) Craver JK et al. (2017) J Am Soc Hortic Sci., 142(1)
(6) Aune D et al. (2017) Int J Epidemiol., 46(3):1029–56

Acknowledgements
We thank Sarah Auld for her technical support