Master's Thesis Engineering Technology

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Growth and nutritional value of a selection of microgreen plants under space conditions to evaluate their use as astronaut's food

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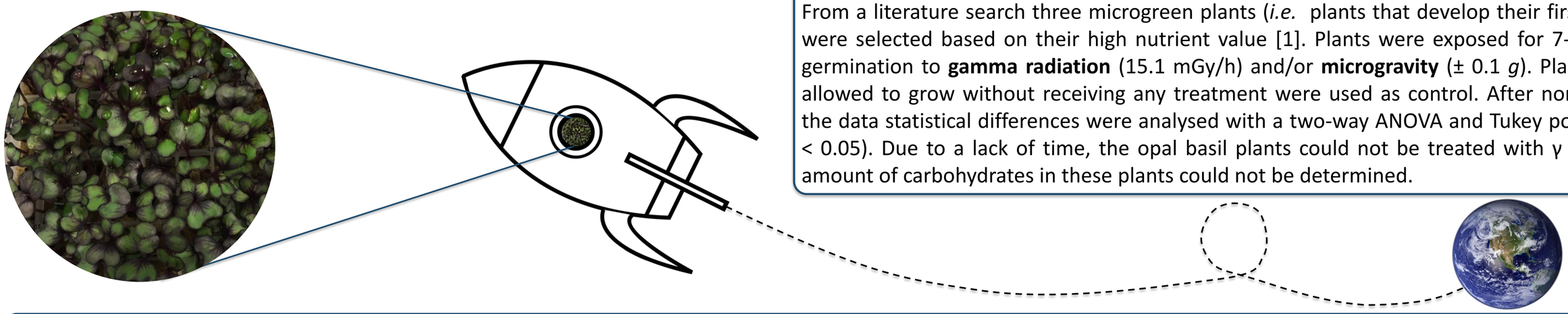
Introduction and Aim

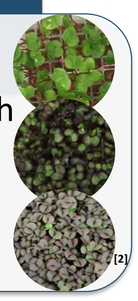
The Belgian nuclear research centre (SCK•CEN) performs research on peaceful applications of radioactivity in society. One of their goals is to determine the effect of space radiation and reduced gravity on the growth and **nutritional value** of young plants called **microgreens**. These plants are of interest as potential food for astronauts on long-term missions because they have a **higher nutrient value** compared to their full grown varieties and can be grown in small closed environments. The aim of this thesis is to determine whether the **adverse space conditions**, namely microgravity and increased radiation, have an influence on the growth and several aspects of the nutritional value of a selection of microgreens.



Material and Methods

3 microgreen species

Red arrow radish
Red cabbage
Opal Basil



Cultivation

7-14 days

Treatments:

- Gamma (**γ**) radiation
- Gamma (**γ**) radiation + microgravity (**μg**)
- Microgravity (**μg**)
- Control

Nutritional value

Protein content
Antioxidative capacity
Carbohydrates
Pigments

From a literature search three microgreen plants (*i.e.* plants that develop their first real leaves) were selected based on their high nutrient value [1]. Plants were exposed for 7-14 days after germination to **gamma radiation** (15.1 mGy/h) and/or **microgravity** (± 0.1 *g*). Plants that were allowed to grow without receiving any treatment were used as control. After normalisation of the data statistical differences were analysed with a two-way ANOVA and Tukey post-hoc test ($p < 0.05$). Due to a lack of time, the opal basil plants could not be treated with γ + μ*g* and the amount of carbohydrates in these plants could not be determined.

Results

This pilot study focusses on the analysis of the general effects of μ*g* and γ radiation. Table 1 gives an overview of the results of the different analyses that were conducted on the selected plants.

General

- Fresh weight decreases under γ radiation and gamma radiation plus microgravity.
- Except for fresh weight and proteins most of the tested parameters showed a species specific response.
- Radiation induced an increase in proteins possibly caused by the expression of proteins that play a role in stress defence like heat shock proteins [3] whereas microgravity treatment causes a decrease in proteins.
- Increase in antioxidants indicates the formation of more free radicals.

Table 1: Effect of radiation, microgravity or both on different nutritional values in three microgreen plants red arrow radish, red cabbage and opal basil with reference to the control samples. ↑ there is a significant increase, ≈ there is no significant change, ↓ there is a significant decrease

	Fresh weight	Proteins	Antioxidative capacity		Pigments			Carbohydrates	
			Hydro-philic	Lipophilic	Chlorophyll a	Chlorophyll b	Carotenoids	Sugar	Starch
Red arrow radish									
μ*g*	≈	↓	≈	≈	≈	≈	≈	≈	↓
γ	↑	≈	≈	↑	≈	≈	≈	≈	≈
γ + μ*g*	≈	↑	≈	≈	↓	↓	↓	≈	↓
Red cabbage									
μ*g*	↑	↓	↓	↓	≈	≈	≈	↓	↓
γ	↓	↑	↑	≈	↑	↑	↑	↑	≈
γ + μ*g*	↓	↑	≈	↓	≈	≈	≈	≈	↓
Opal basil									
μ*g*	↑	↓	≈	≈	↓	≈	↓		
γ	↓	↑	≈	↓	≈	≈	≈		

Red arrow radish

- Decrease in pigments should lead to a reduction in photosynthetic activity and subsequently in carbohydrates.

Red cabbage

- Increased pigments can cause the higher levels of carbohydrates due to higher photosynthetic activity.
- Decreased carbohydrates can be caused by an increased need for energy.
- More susceptible to radiation and μ*g* than radish, but less differences when treated with the combination.

Opal Basil

- Decrease in pigments can lead to reduced photosynthetic activity.

Conclusion

The results of this research showed that the nutritional value of selected microgreens was differently affected by radiation, microgravity or the combination of these factors. While **radish** plants that experienced microgravity or radiation alone were not affected, **combining** these **treatments** induced a **decrease** in **photosynthetic pigments** which could lead to a lower photosynthetic activity. The **red cabbage** plants are more susceptible with changes in antioxidants and pigments to radiation and microgravity but show **less significant differences** when they are **treated** with the **combination** of these factors. The **opal basil** plants could not be treated with the combination of microgravity and radiation but showed a **decrease** in **pigments** when the plants experienced **microgravity**. Hence this pilot study showed that the **nutritional value** of plants is overall **affected by adverse space conditions** and this in a **plant dependent way**.

Further research

- Repeat to obtain more samples
- Other nutritional parameters
- Additional growth related parameters: photosynthetic activity and carbohydrates
- Lignin and anthocyanin levels

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References

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[3] S. Ghosh, P. Sarkar, P. Basak, S. Mahalanobish, and P. C. Sil, 'Role of Heat Shock Proteins in Oxidative Stress Tolerance', in Heat shock proteins and stress, 15th ed., A. A. A. Asea and P. Kaur, Eds. Cham: Springer, 2018, pp. 109–126