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Microgreens- A Boon to Human Health: Nutritional, Functional and Safety Perspectives: A Review

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Abstract
Microgreens now a days have evolved as an ultra-modern class of functional foods. They are defined as young edible tender shoots and seedlings, harvested 7 to 21 days after germination. They are fresh & ready to eat functional food mostly rich in vitamins, antioxidants, minerals, phytochemicals, and bioactive compounds, with distinct flavors, colors and textures. Therefore, they are mostly used as salads in households and hotel industry. They are one of the most preferred choices for astronauts in space farming. They are beneficial and can be considered global nutritional food as they grow very fast with minimum load in small area for full year. The potential health benefits of Microgreens are mediated through action of micro nutrients and phytochemicals by antioxidants activity, anti-inflammatory effects, gut microbiota interaction, chemo-preventative pathways and cardio protective actions. They are very beneficial for patients who are at risk of deficiency in iron, zinc and vitamins. Microgreens are considered as boon for human health as they prevent obesity, cancer, diabetes, cardiovascular & kidney ailments. Consumption of micro green poses microbiological risk due to contamination, short shelf life and post-harvest handling. Current study suggests that Microgreens are micro nutrient dense which provides substantial nutrient benefits while also being lower in calories. Therefore, we should enhance the inclusion of diverse Microgreens to support public health by chronic disease prevention.
***Keywords**: Microgreens, functional food, bioactive compounds, antioxidants, space farming, cardiovascular, food safety, shelf life, chronic disease prevention.*

Introduction

Microgreens are considered as conservation-oriented agriculture, which makes it low input crop along with high nutritional value. Basically, Microgreens are tender, edible seedlings of vegetables, herbs, and flowering plants harvested after the cotyledonary leaves have fully opened (Zhang et al., 2021; Tan et al., 2020; Sharma et al. 2022; Rouphael et al., 2021; Du et al., 2022). They gained increased popularity due to their fresh taste and nutritional benefits over the past decade (Lenzi et al., 2019). Microgreens are better substitute for sprouts due to their rich nutritional content and more intense flavour, taste and low calorie (Lenzi et al.,2019).

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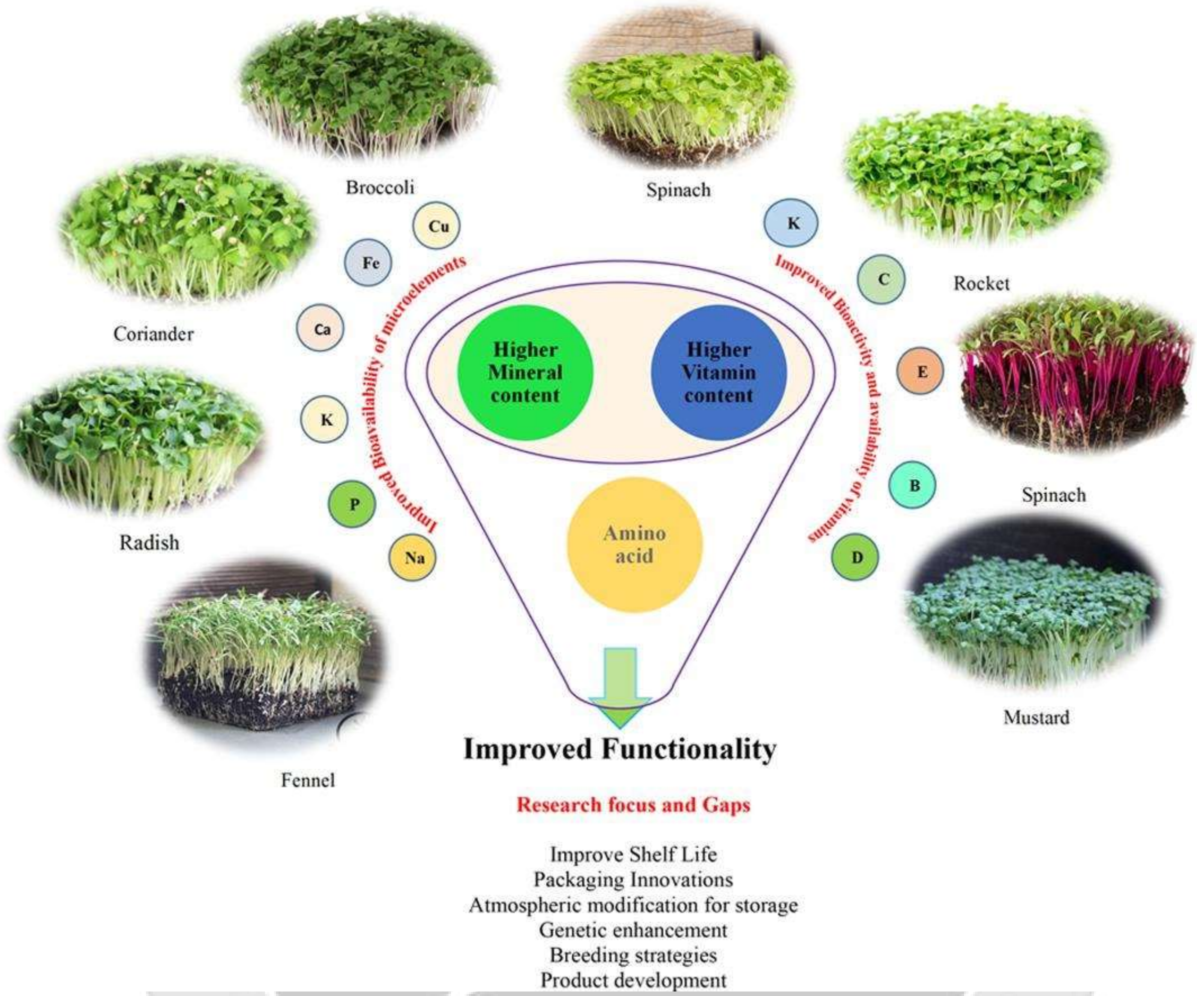

Figure 1: Microgreens: rich source of nutrition, research focus and gaps. (Sharma et al., 2022)

Microgreens are a rich source of different vitamins (A, C, E and K)(Tan et al.,2020; Ghoora et al.,2020; Choe et al.,2018; Acharya et al.,2021;Xiao et al.,2012;Xiao et al.,2019;Yadav et al.,2019) minerals (K, Ca,Fe,Zn,P,S,Mg,Mn,Cu & Na)(Weber,2016; Xiao et al.,2016, Paradiso et al.,2018; Kyriacou et al.,2021) and health promoting compounds such as phenolic compounds, amino acids, glucosinolates , and glycero-phospholipids (Ghoora et al.,2020; Acharya et al.,2021; Brazaityte et al., 2015; El-nakhel et al.,2021; Castellaneta et al.,2022; Kaur et al.,2022). Therefore, incorporating Microgreens in diet can enhance the nutritional value which contributes to better health for consumers (Zhang et al.,2021). Despite huge benefits, certain challenges are observed which includes short shelf life, delicate nature, microbial growth, contamination, and post-harvesting challenges.

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Microgreens have grown in popularity in recent years. The historical roots of Microgreens date back to 1930s when Northern American pharmacies sold, dried wheat grass for medicinal use (Choe et al., 2018). The first scientific study on enhancing Microgreens growth through sea treatments were published in US(Lee et al.,2004). By 2010, Microgreens gained popularity in research in USA, Italy and India (Puente et al., 2024).

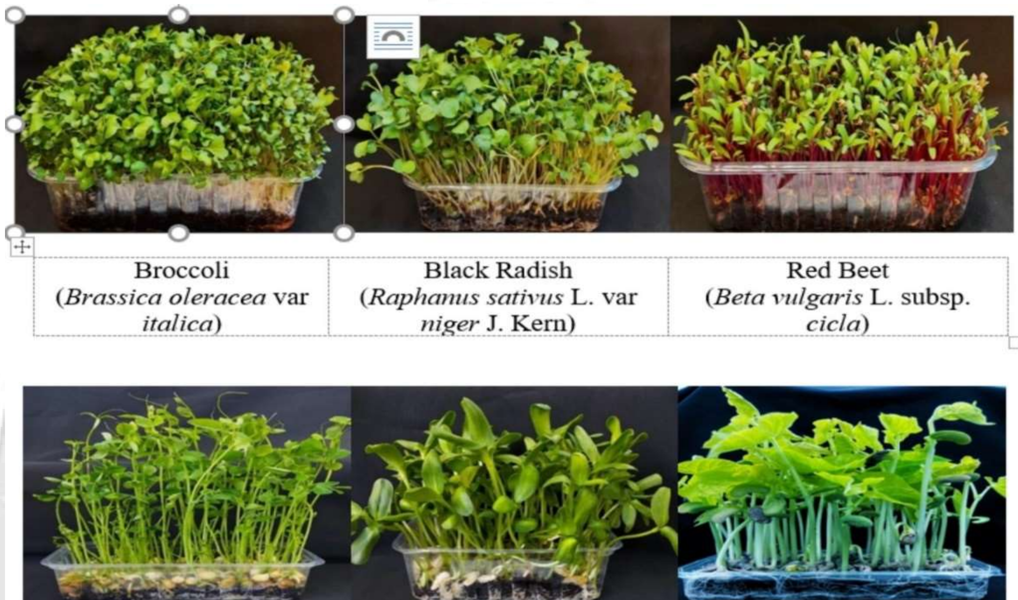

Figure 2: Images of microgreens from six different plant species grown in the study. Depending on the species, microgreens were harvested 7 to 21 days after germination. This time frame was when the first true leaves developed, following the initial cotyledon leaves. (Source: Balik et al., 2025)

The global microgreens market can be characterized into four main segments namely (i) Green type (ii) Farm type (iii) End product uses (iv) regional markets [Globe Newswire Europe (GNU), 2023].

Microgreens consist of central stem and a pair of true leaves that start to emerge (Kyriacou et al., 2016; Choe et al., 2018). Di Gioia et al. (2017) declare that not all tender young plant greens are considered Microgreens. The size of them is approximately 1 to 3 inches tall and they are harvested on average between 7-14 to 21 days, post planting.

Baby green and sprouts, in addition to Microgreens, are recognised and primary differences are provided in (Table 1).

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Table 1: Culturd and Morphological Differences: Sprouts, Baby Grees and Micro Greens

Growth Phase	Harvest Time (Days)	Size (Inches)
Sprouts	From 2 to 6	From 0.8 to 1
Baby Greens	From 15 to 40	From 2 to 4
Microgreens	From 7 to 21	From 1 to 3

Taxonomic Diversity

The key plant families used for Microgreens production includes more than 13 families including Brassicaceae (broccoli, kale, mustard, radish, cabbage), Amaranthaceae (amaranth, beet), Fabaceae (pea, lentil, chickpea), Apiaceae (carrot, dill, celery), Poaceae (wheat, barley, maize), and Lamiaceae (basil, mint) (Seth et al, 2025).

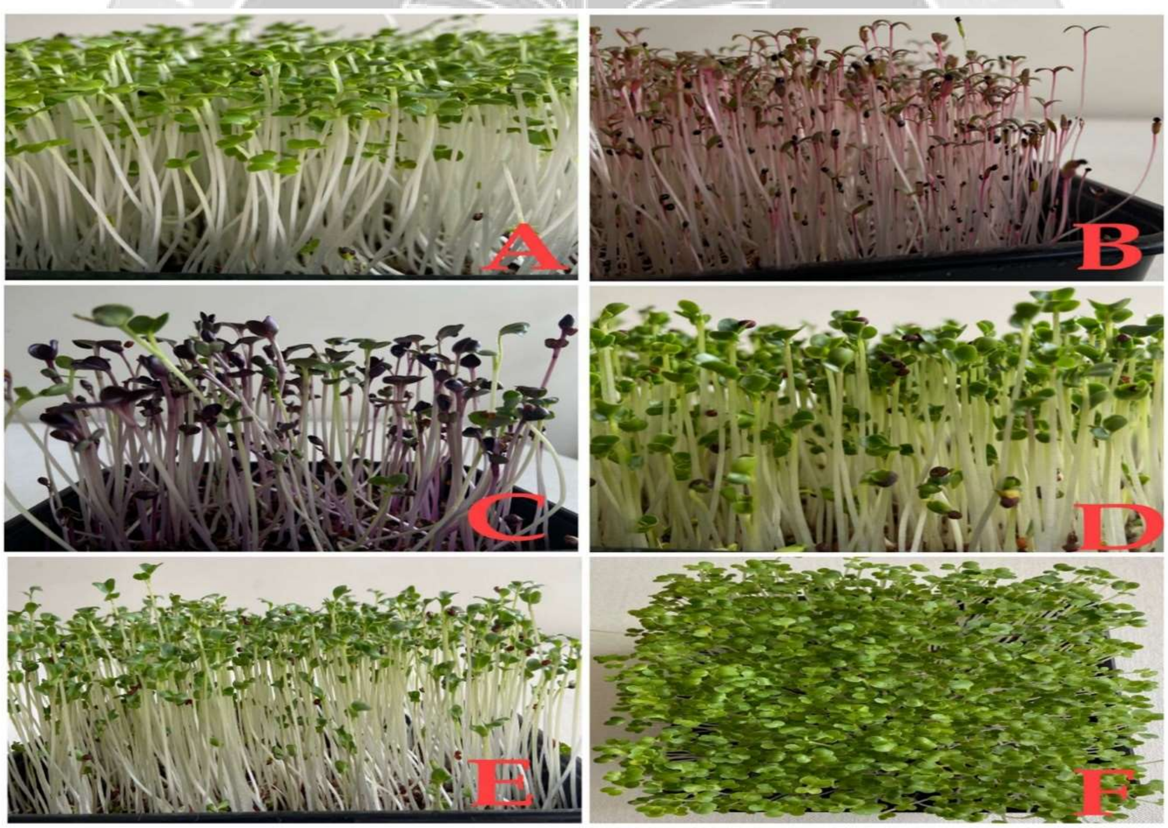

Figure 3: Different microgreens grown in a lab. (A) Bok choy, (B) Red amaranth, (C) Purple radish, (D) Kale, (E) Broccoli, and (F) Bok choy—top view. (Source: Bhaswant et al., 2023)

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Brassicaceae species are particularly well studied due to their glucosinolate content and associated health benefits (Dereje et al.,2023) Solanaceae crops such as tomato and eggplant are generally avoided at the Microgreens stage because of potentially higher levels of anti-nutritional or toxic alkaloids (Seth et al, 2025).

Microgreens: Space Farming
Microgreens offer an ideal carotenoid rich food for space farming as a part of space life support system (SLSSs) (Perchonok et al.,2012) as they require low photon flux and can be grown on synthetic media with little or no nutrient supplementation (Teng et al., 2023). Microgreens are ideal candidates for astronauts' functional salads (Kyriacou et al., 2017) due to their requirement of low inputs and quick turn-around time when power, mass,and volume constraints prohibit the growth of crops to maturity.

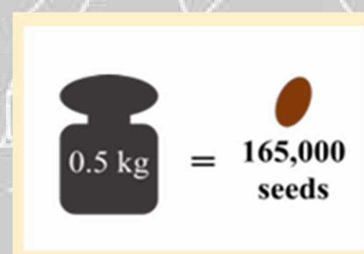

Figure 4: It would take 10.9 years to use 0.5 kg of seeds. (Source: Johnson, 2019)

During space flight missions, more than 1.90 kg of edible biomass can be harvested annually from a 40 cm^2 growth chamber by growing 26 crops of Microgreens (Johnson, 2019). Around 1.00 kg of seeds is sufficient for 3-month production during a space mission, as 1.09 and 1.36 kg of fresh biomass can be produced from 6-7g of seeds of cabbage and radish, respectively (Amitrano et al., 2023). Therefore, 20 meals can be produced considering 50g Microgreens per meal (Seth et al., 2025).

Figure 5: With a 40 cm^2 growth chamber, we can produce 26 crops of microgreens per year, and yield >1.9 kg of edible biomass. (Source: Johnson, 2019)

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Microgreens: Nutrition

Micro green popularity is skyrocketing due to a variety of nutritional and chemical factors. The pilot study confirmed effectiveness in the reduction of blood glucose, weight control, and cardiovascular disease prevention. The high bio accessibility of phytochemicals after digestion can provide the antimicrobial, anti-inflammatory, antioxidant, or anti-diabetic potential of Microgreens (De La Fuente et al., 2020; Le et al., 2020).

Multiple compositional studies consistently show that Microgreens are enriched in essential micro nutrients, relative to mature leaves. Comparative analysis suggests that Microgreens of 25 Brassicaceae family and other vegetables provided 2-12% of recommended daily intake (RDI) of iron, 2-13% of zinc, 1-6% of selenium, 28-116% of Vitamin C,28-332% of Vitamin E and 24-72% of Vitamin A per 100g fresh weight (Seth et al.,2025).

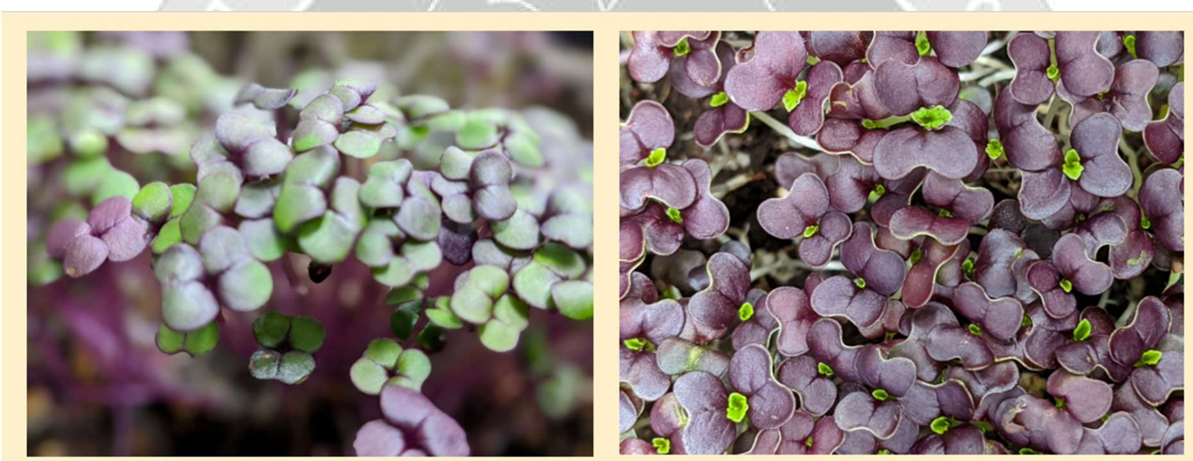

Figure 6: Red Cabbage; Brassica oleraceavar. Capitata; Garnet Giant Mustard; Brassica juncea (Source: Johnson, 2019)

Micro and macronutrients (Ca, Mg, F, Fe, Zn,Cu, Se & Mo) are widely present in broccoli, Chinese cabbage, radish, China rose, Cabbage Red (Pinto et al.,2015), green purple basil, coriander, mustard, radish (Kyriacou et al., 2019; Kyriacou et al.,2020), pea, sunflower (Poudel et al.,2023) and black gram, moong beans and chickpeas (Kaur et al., 2022). They are extremely rich in vitamin C, K and E present in coriander, mustard, radish, green and purple basil, jute (Kyriacou et al., 2019; Kyriacou et al.,2020), fennel (Ghoora et al.,2020), lettuce (Pannico et al.,2020), and broccoli (Kathi et al.,2023).

Lutein is present in basil, parsley, mustard (Samuolienė et al.,2016; Craver et al.,2017), amaranth (Kyriacou et al.,2019), cabbage, and radish (Amitrano et al.,2023). Along with that neoxanthin and violaxanthin is present in cabbage and radish (Amitrano et al.,2023). Red basil is rich in caffeic

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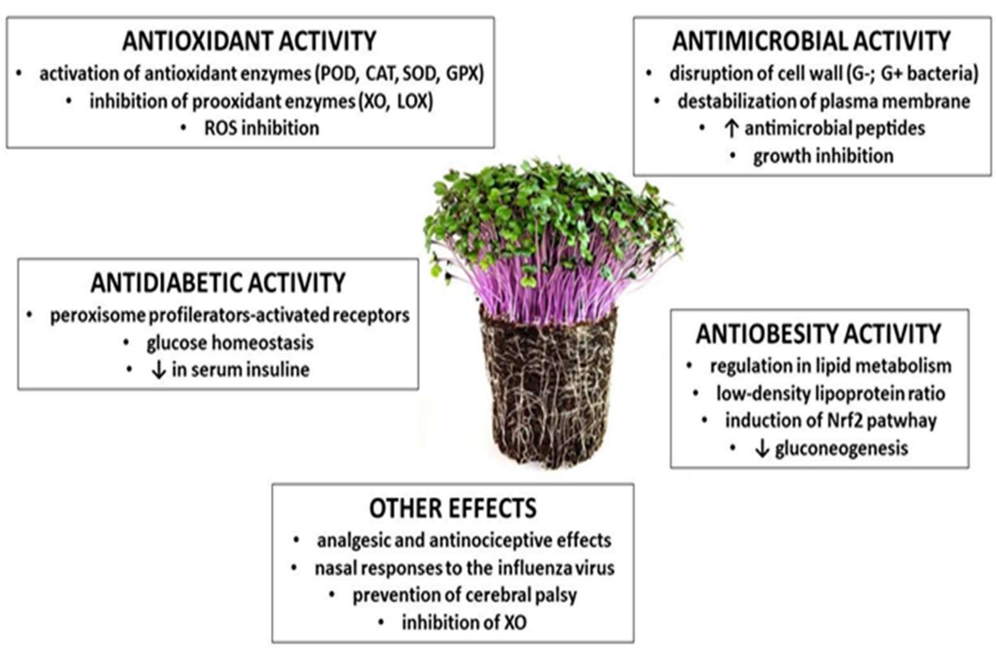
acid and rosmarinic acid (Lobiuc et al.,2017). Phytochemicals (polyphenols, flavonoids, antioxidant activity) were seen in bottle gourd, cucumber, pumpkin, amaranthus, jute, spinach (Yadav et al.,2019), finger millets, green peas, soyabean (Zhang et al., 2019), moong bean (Ma et al., 2022) and red amaranth (Gunjal et al.,2024).

Health Benefits
Microgreens are being recognized as functional food and have become increasingly popular in western countries (Kyriacou et al., 2017; Mir et al., 2017). Microgreens have their effectiveness in blood glucose and weight control. Overleaf regulation of adipose tissue lay the foundation for studying the potential value of Microgreens on preventing and treating chronic diseases, such as obesity, type two diabetes and cardiovascular diseases (Sun et al., 2020; Huang et al.,2016). Microgreens help in digestion due to high percentage of total phenolics and glucosinolate levels. The high bioaccessibility of these bioactive compounds after digestion can provide anti-inflammatory, anticancer, antimicrobial, and anti-diabetic activities(Le et al., 2020). Anti proliferative effects of Microgreens on colon cancer cells were also observed (Feunte et al., 2020).

Figure 7: Another biological activity of microgreens. Abbreviations: ROS – reactive oxygen



species, XO – xanthine oxidase, LOX – lipoxygenase, POD – peroxidase, CAT – catalase, SOD – superoxide dismutase, GPX – glutathione peroxidase, G- - Gram-negative bacteria G+ -Gram-positive bacteria, Nrf2 - nuclear factor erythroid 2-related factor 2
(Source: Jambor et al.,2022)

Huang et al. [2016] investigated the effects of red cabbage Microgreens on modulating hypercholesterolemia in obese mice induced by high fat diet. Rats fed with a high fat diet and red cabbage Microgreens powder showed a significantly lower plasma low density lipoprotein (LDL) level and lower hepatic triglycerides level compared with those receiving a high fat diet supplemented with mature red cabbage powder. Huang et al. (2016) describe inhibition of cholesterol and triglycerides synthesis, together with regulation of plasma and liver lipid metabolism. Due to the richness of vitamins and phytochemicals, Microgreens have a strong antioxidant capacity and are effective in the regulation of plasma lipoprotein and cholesterol metabolism, showing a potential value in the prevention and/or treatment of chronic diseases (Zhang et al., 2021).

Microgreens and Functional Mechanism

There is a novel functional mechanism which links Microgreens to human health. The potential health benefits of microorganisms are mediated primarily through the action of their micronutrients and phytochemicals. The biological activity of microorganisms includes proposed mechanism:

a) **Antioxidant activity** – Vitamins C and E, carotenoids and phenolic compounds scavenge reactive oxygen species, reduce oxidative damage to lipids, proteins and DNA, and up-regulate endogenous antioxidant enzymes such as superoxide dismutase and glutathione peroxidase (Bhaswant et al., 2023; Balik et al., 2025)

b) **Anti-inflammatory effects** – Polyphenols and isothiocyanates can inhibit NF-κB signalling, down-regulate pro-inflammatory cytokines (e.g., TNF-α, IL-6) and modulate eicosanoid synthesis, thereby attenuating low-grade chronic inflammation implicated in metabolic and cardiovascular diseases(Bhaswant et al., 2023;Jambor et al., 2022)

c) **Modulation of glucose and lipid metabolism** – Animal studies suggest that phenolic-rich microgreen extracts improve insulin sensitivity, reduce fasting glucose and modulate lipid profiles via AMPK activation, improved GLUT4 translocation and inhibition of hepatic lipogenesis (Bhaswant et al., 2023).

d) **Gut microbiota interactions** – Dietary polyphenols and fibre serve as substrates for colonic microbiota, leading to production of short-chain fatty acids and other metabolites that support gut barrier integrity and systemic metabolic health (Jambor et al., 2022).

e) **Chemopreventive pathways** – Glucosinolate-derived isothiocyanates, such as sulforaphane from broccoli Microgreens, induce phase II detoxification enzymes (e.g., NQO1, GSTs), promote apoptosis in initiated cells and may inhibit tumour growth in experimental models (Dereje et al.,2023).

f) **Cardioprotective actions** – Antioxidant and anti-inflammatory effects, together with improved lipid profiles and endothelial function, provide a mechanistic rationale for potential reductions in atherosclerosis and hypertension risk (Jambor et al., 2022).

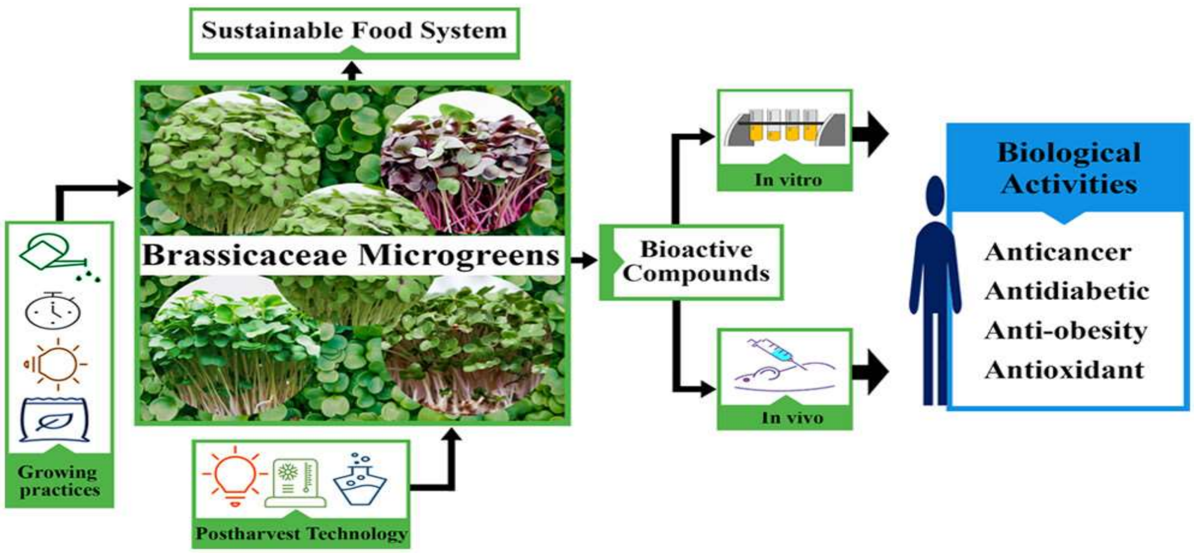


Figure 8: Microgreen's functional mechanism in a nutshell (Source: Dereje et al.,2023)

Collectively, these mechanisms support the hypothesis that regular consumption of Microgreens could contribute to the prevention or attenuation of multiple non-communicable diseases (NCDs), although direct human evidence remains limited.

Microgreens and Safety Perspective

Microgreens are vulnerable to bacterial internalization. During germination, the seed releases a mix mixture of carbohydrate and peptide that can attract microbes present in rhizosphere (Warriner et al., 2003). More microbial contamination is found on hydroponic over soil or growing media (Riggio et al., 2019). Microbial contamination is due to the constant warm temperature and humid condition of the hydroponic system (Turner et al., 2020). Salmonella (Reed et al., 2018) and Escherichia Coli (Xiao et al.,2015) are common pathogens responsible for microbial activity in microgreens.

According to Riggio et al., (2019) microbial contamination can be easily overcome through good agriculture practices like use of uninfected seeds, seed treatments, clean & sanitized utensils and use of UV for disinfection of hydroponic systems. Since micro greens are young and tender, so they must be handled with care, rapid cooling and gentle handling, which can reduce wilting and quality loss (Seth et al., 2025). While no foodborne illness outbreaks have yet been attributed to microgreens (Yaergin et al., 2023), they remain classified as a potential transmission route for bacterial pathogens (Xiao et al.,2015).

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Good hygiene practices in indoor farms and appropriate cold chain maintenance during storage and distribution are the various strategies for risk mitigation by pathogens (Seth et al.,2025). Microgreens generally contain low level of nitrates, oxalates and trypsin inhibitors, which remain within safe limits for human consumption (Seth et al., 2025). However, nutrients solution and substrates can influence accumulation of nitrates and heavy metals, so careful management of fertilizer and growing media is required, especially in urban industrial areas (Seth et al.,2025).

The greatest shelf life of microgreens is achieved by selling the still rooted microgreens in growth medium. Harvested microgreens must be kept in cold to maintain quality (Chandra et al., 2012; Mir et al., 2017). High humidity is necessary to prevent dehydration (Zagory & Kader, 1988).The available information on the microbial safety of microgreens is still inadequate. Comprehensive studies are necessary to examine the persistence and growth of foodborne pathogens on microgreens exposed to diverse environmental, storage, and temporal conditions (Di Gioia et al., 2017).

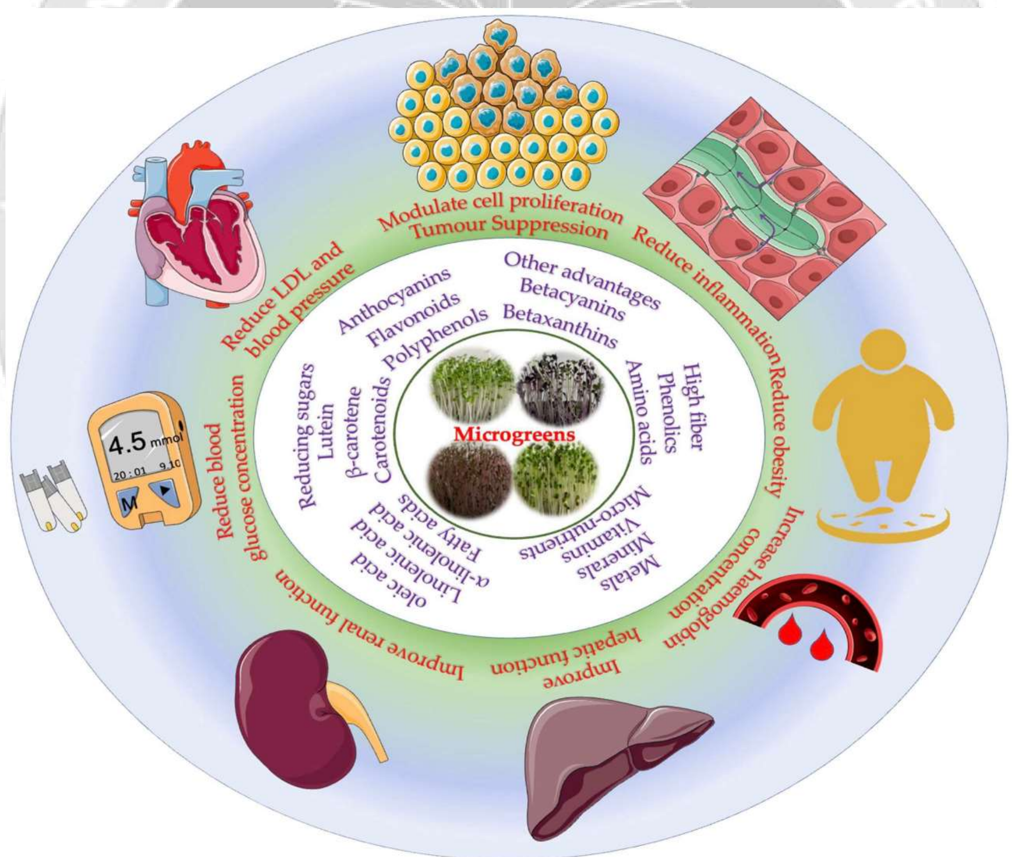

Figure 9: Overview of health benefits of microgreens (Source: Bhaswant et al., 2023)

Conclusion

Microgreens are divine food supplement that can be considered as a boon to human health as they are fully loaded with the macro and micro nutrients, proteins, vitamins, minerals, bioactive phytochemicals, flavonoids, anthocyanin. Microgreens are more nutritive than mature vegetables. They have antioxidant, anti-inflammatory, antibiotic, antiobesity, antimicrobial, anti fungal properties. They also have metabolic and potential chemo preventive effects. In resource constrained and urban environment microgreens play a vital role to supply improved micro nutrients and dietary diversity. This functional food production requires less input, time, effort and investment and provides more profit. Microgreens are heroic food among astronaut as they are carotenoid rich food for space farming. Microgreens provide tremendous health benefits which leads to treatment and prevention of non-communicable diseases (NCDs) such as obesity, type two diabetes, cardiovascular diseases, cancer etc. Consequently, microgreens have gained attention in gastronomy and nutritional science over time. They have intense flavours and vibrant colors so they are used as salads in homes as well as hotel industry. Microgreens also possess strong consumer appeal due to their vibrant visual appearance, distinct flavors profile, and crisp texture, all of which serve as indicators of freshness and quality. These attributes collectively contribute to a more satisfying sensory and overall eating experience. Microgreens if not grown in hygienic conditions and rigorous sanitization will have maximum chances of microbial contamination like salmonella, E. Coli and listeria. They should be stored at low temperature to increase shelf life, and slow spoilage. Although this review reveals nutritional health beneficial aspects of microgreens but future research is needed to justify the characterization of microgreens as a 'boon to human health'. Future research must inculcate well designed human trials, comprehensive safety assessment, and integrated evaluation of sustainability and social economic impact. In the interim, emphasizing the inclusion of diverse microgreens within a plant-rich dietary pattern may serve as a pragmatic strategy to enhance nutritional intake and support broader public health outcomes.

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