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# **Exploring the Potential of Microgreens for a Functional Food: Health Benefits, Cultivation Techniques & Future Directions**

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**ABSTRACT:** Microgreens is the young seedlings of vegetables and herbs harvested 7-21 days post-germination, they have emerged as a promising food due to their high nutrient density and bioavailability. This study is compiled using existing research on microgreens, focusing on their health benefits such as improved insulin activity and lipid metabolism in type 2 diabetes model, and their cultivation under various conditions and circumstances, including hydroponic systems and preharvest treatments like calcium chloride and UVB irradiation. Through a comprehensive review of the literature and experimental data, this paper highlights the nutritional content of microgreens and their potential in sustainable food systems, the challenges of short shelf life and limited growth and yield. Recommendations for future research will include optimizing growth conditions and expanding human trials.

**KEYWORDS:** Microgreens, Health benefits, Cultivation technique.

## **I. INTRODUCTION**

The global rise of chronic diseases like type 2 diabetes (T2DM) has emphasised the importance of dietary interventions for the prevention and management. Microgreens, are the early stage seedlings of edible plants which have gained attention for their concentrated levels of vitamins, minerals, polyphenols and glucosinolates compounds which are linked to health benefits. Broccoli microgreens, specifically have shown promise in enhancing insulin activity, cutting body weight and improving metabolic profiles in preclinical studies. Thus advancements in cultivation techniques, such as hydroponics and vertical farming, offer sustainable production methods to meet growing food demands.

**This research paper aims to:**

1. Review the nutritional and therapeutic potential of consumption of microgreens.
2. Analyse their cultivation techniques and their impact on growth and quality.
3. Identify gaps in research and propose directions for future studies.

## **II. LITERATURE REVIEW**

Microgreens have been extensively studied for their bioactive compounds and their health benefits. Research shows that broccoli microgreens are rich in glucosinolates, which improves lipid metabolism in mice (Li et al., 2021). Similarly, preharvest calcium chloride treatments increase glucosinolate content and extend its postharvest quality (Kou et al., 2023). Studies on kale and broccoli microgreens reveal that higher polyphenol and GL levels under controlled chamber conditions compared to window side growth (Chen et al., 2022).

Hydroponic systems have shown to improve growth and quality in basil microgreens, Swiss chard and rocket microgreens (Bulgari et al., 2021). Light spectrum manipulation, particularly blue and red LED light ratios, enhances the biomass and nutrient content in Brassicaceae microgreen plant (Brazaityte et al., 2024). Vertical farming and controlled environment ecosystems further optimize resource use which addressed food insecurity in urban settings (Sharma et al., 2024).

Despite these advances, challenges remain like the Microgreens short shelf life limits commercial viability, which will need improved storage conditions (Xiao et al., 2014). Additionally, while preclinical studies show the therapeutic potential, human trials were rarely done which highlights a critical research gap.

### **III. RESEARCH METHODOLOGY**

This study integrates literature review with experimental data. Key methodologies from referenced studies are included from

1. Preclinical Trials: Diabetic mice fed a high fat diet were treated broccoli microgreen juice through gavage for 18 weeks to assess impacts on their body weight, glucose tolerance, and lipid metabolism (Li et al., 2021).
2. Cultivation Experiments: Broccoli microgreens were treated with 10 mM  $\text{CaCl}_2$  preharvest, followed by metabolic profiling (Kou et al., 2023). Kale and broccoli microgreens were grown in chambers on window side for 10 days to compare secondary metabolite profiles (Chen et al., 2022).
3. Hydroponic Studies: Basil, Swiss chard, and rocket microgreens were cultivated in hydroponic system setup with yield and quality assessed through quantitative analysis (Bulgari et al., 2021).
4. Light Spectrum Trials: Brassicaceae microgreens were exposed to varying blue and red LED ratios with biomass and nutrient content measured (Brazaityte et al., 2024).

Data were sourced from peer reviewed articles (e.g., MDPI, ACS, Wiley) and analysed qualitatively and quantitatively to identify trends and gaps in research

### **IV. DISCUSSION AND ANALYSIS**

The findings underscore that microgreens nutritional superiority. Mice treated with broccoli microgreen juice which exhibited reduced body weight, lower fat percentage and improved glucose tolerance (Li et al., 2021). Calcium chloride treatments also enhanced glucosinolate levels in broccoli microgreens, improving both nutritional value and shelf life (Kou et al., 2023). Growth conditions significantly influenced the metabolite profiles with chamber grown kale and broccoli microgreens showing higher hydroxycinnamic acid esters and flavonols (Chen et al., 2022).

Hydroponic systems increased shoot dry matter and water content in basil, Swiss chard and rocket microgreens plant, while hemp mats outperformed other substrates in beetroot microgreen trials (Moraru et al., 2021). Light spectrum adjustments, particularly higher blue light ratios, positively impacted morphology and also phytonutrient accumulation (Brazaityte et al., 2024).

However, environmental factors such as humidity and pathogen activity on these plants remain underexplored in this field, affecting production consistency (Rochette et al., 2021). Storage conditions also play a critical role in lower temperatures (5°C) and bioplastic packaging extended its shelf life by 8-10 days (Xiao et al., 2014).

### **V. FINDINGS**

Key findings include:

1. Health Benefits: Broccoli microgreens reduce body weight and enhance insulin activity in mice, attributed to high GL content (Li et al., 2021).
2. Cultivation Optimization: Preharvest  $\text{CaCl}_2$  and UVB treatments boosted the glucosinolate levels and postharvest quality (Kou et al., 2023; Dong et al., 2022).
3. Hydroponic Advantages: Microgreens grown hydroponically exhibited greater yield, water content, and nutrient density (Bulgari et al., 2021).
4. Nutritional Profile: Beetroot and amaranth microgreens are rich in pigments and antioxidants, peaking during the early growth (Niraola et al., 2021).
5. Shelf Life: Storage at 5°C with bioplastic packaging enhances quality and extends it's freshness (Xiao et al., 2014).

### **VI. LIMITATIONS**

1. Preclinical Focus: Most health benefit studies were conducted on mice which limits applicability to humans (Li et al., 2021).



2. Environmental Gaps: Full ranges of environmental factors were not consistently considered properly. (Rochette et al., 2021).
3. Shelf Life: Microgreens short shelf life restricts its market potential, with studies often lacking long term storage in analysis (Xiao et al., 2014).
4. Scope: Many studies focused on some specific varieties (e.g., broccoli, beetroot), limiting generalizability (Chen et al., 2022).

## **VII. DISCUSSIONS**

The discussion shows these findings, emphasizing microgreens potential as a functional food with various health benefits, particularly for type 2 diabetes, but with a lack of human trials to confirm benefits. It discusses the commercial challenge of short shelf life, suggesting there should be further research into storage and packaging technologies. Environmental factors like humidity and pathogen activity are not taken into consideration, needing attention for consistent production. This also explores implications for sustainable food systems, positioning microgreens as a viable option for urban farming and healthy lifestyle.

## **VIII. RECOMMENDATIONS**

1. Conduct human clinical trials to validate the findings.
2. Investigate additional environmental factors such as humidity and microbial contamination to optimize growth.
3. Develop advanced packaging and storage technologies to extend its shelf life.
4. Expand research to diverse the microgreen species and cultivation systems

## **IX. CONCLUSION**

Microgreens represent a nutrient dense, sustainable food source with significant health benefits observed, particularly in managing metabolic disorders. Advances in hydroponics, light spectrum manipulation and preharvest treatments will enhance their production and quality. However, addressing shelf life limitations and scaling human studies are necessary for realizing their full potential. As global food systems evolve, microgreens offer a promising solution improving dietary health and sustainability.

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