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Review paper

Microgreens as Nutritional, Functional and Agricultural Potential

Prerna Mitra* [a], **V. Sudhakar Rao** [a], **R. P. Singh** [b]

[a] *Department of Botany, Govt. P. G. College, Mandsaur, India*
[b] *Department of Botany, Govt. K. R. G. P. G. College, Gwalior, India*

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***Corresponding author**
Prerna Mitra
✉ **Email**
prerna.mitra17@gmail.com

ABSTRACT

Microgreens, the tender seedlings of vegetables and herbs harvested shortly after cotyledon development, have emerged as a high-value crop in both culinary and nutritional contexts. This review synthesizes existing literature on their origin, cultivation methods, nutritional composition, phytochemical profile, functional properties, market potential, and safety considerations. Evidence indicates that microgreens contain significantly higher concentrations of vitamins, minerals, and bioactive compounds than mature plant tissues, offering antioxidant, anti-inflammatory, and potential chemopreventive benefits. Advances in controlled environment agriculture, including hydroponics and LED lighting technologies, have enabled consistent production with optimised yield and quality. However, challenges remain in ensuring microbial safety, extending post-harvest shelf life, and standardising cultivation protocols for diverse climatic conditions. The growing consumer demand for nutrient-dense, sustainable foods positions microgreens as a promising component of urban agriculture and public nutrition strategies. Further interdisciplinary research is essential to fully realise their potential in health promotion and sustainable food systems.

1. Introduction

Microgreens also known as vegetable confetti, are edible tender greens harvested shortly after development of cotyledon leaves usually about 7–21 days after germination[1]. Microgreens differ from sprouts in the way they are grown in a medium and exposed to light, resulting in the development of true leaves before harvesting. In recent years, micro greens popularized due to their unique flavour, colours, and broad-spectrum nutritional profile. The growing interest of consumer in functional foods and innovations in urban agriculture fuel the rapid expansion of global market[2,3]. Microgreens have nutritional, Functional and Agricultural Potential (Fig. 1).

2. Historical Context and Origin

The concept of consuming seedlings is not new. Historical records from East Asia, Europe, and the Indian subcontinent indicate the use of sprouts and tender plant tissues for culinary and medicinal purposes[4]. However, the term "microgreen" emerged in the United States during the late 1980s, initially associated with fine dining establishments. Advancements in green house and vertical farming cultivation technologies make roads for the commercial production of microgreens in Europe and Asia in past two decades[5].

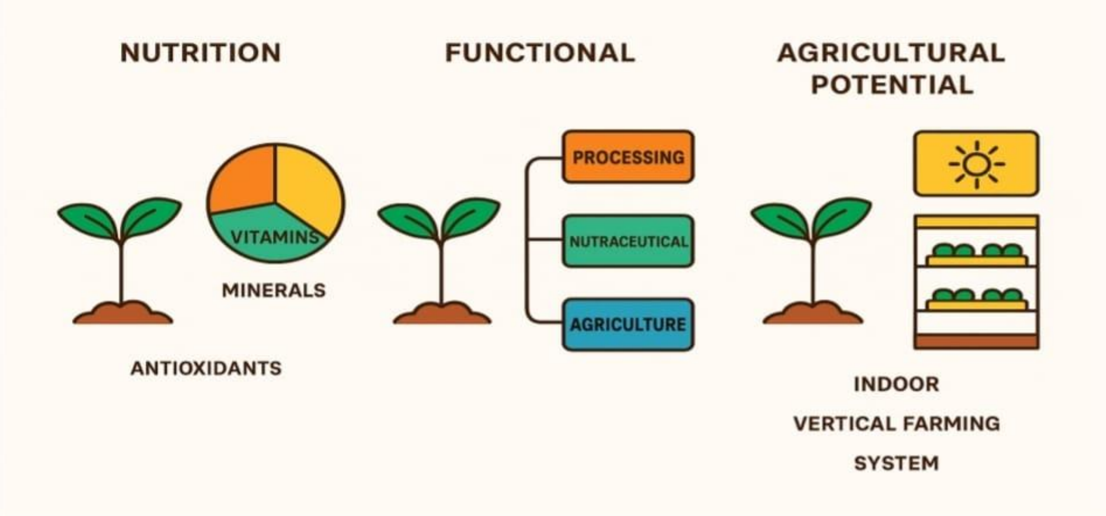

Figure: Schematic representation of microgreens showing their nutritional composition, functional applications, and agricultural potential.

3. Nutritional Composition

Several studies reveal that concentrations of phytochemicals, minerals, and vitamins are on higher side than their mature counterparts. Red cabbage microgreens had up to 40 times higher levels of vitamin E and vitamin C compared to mature red cabbage leaves[1]. Similar observations demonstrated significant amounts of carotenoids, phenolic compounds, and glucosinolates in Brassicaceae microgreens[6]. Nutrient accumulation varies by species and growth conditions such as *Amaranthus* microgreens are rich in iron, magnesium, and polyphenols[7]. High content of vitamin C and essential oils are found in *Coriandrum sativum*. *Brassica oleracea var. italica* (broccoli) microgreens are notable for sulforaphane content, a compound linked to anti-cancer properties[8].

4. Phytochemical and Functional Properties

Microgreens are valued for their bioactive compounds that contribute to antioxidant, anti-inflammatory, and antimicrobial activities. Microgreens as impending natural source of antioxidants which are capable of neutralising free radicals[9,10]. These bioactive molecules influence sensory attributes, contributing to flavour diversity ranging from mild and nutty to pungent and peppery.

5. Production Systems and Technologies

Microgreens can be produced in soil, soilless substrates (coconut coir, vermiculite, perlite), or hydroponic and aeroponic systems[3]. Controlled environment agriculture (CEA) methods, such as LED-assisted growth chambers, have allowed precise control over light spectra and photoperiods to optimise yield and nutritional quality[2].

6. Food Safety Considerations

As microgreens are consumed raw, microbial contamination is a concern. Escherichia coli and Salmonella, a potential pathogen, in un hygienically handled produce[11]. Adoption of Good Agricultural Practices (GAP), controlled irrigation with quality water and care during post-harvest practices are critical for ensuring consumer safety[12].

7. Economic and Commercial Perspectives

The microgreens market has transitioned from niche gourmet applications to mainstream availability in supermarkets and farmer's markets. Global market reports project double-digit compound annual growth rates (CAGR) through 2030[13]. In India, microgreens cultivation is being explored both as a small-scale entrepreneurial venture and as part of urban rooftop farming initiatives[14].

8. Research Gaps

Despite significant advances, several research areas remain underexplored:
Development and optimization of standard cultivation protocol for specific species at different agro-climatic conditions. Post-harvest storage methods to extend shelf life without nutrient loss. Integration into public nutrition programs for combating micronutrient deficiencies. Breeding for improved bioactive profiles.

9. Conclusion

Microgreens represent a sustainable, nutrient-dense, and high-value crop with significant potential in both developed and developing countries. Their short growth cycle, minimal resource requirements, and high market value align with contemporary demands for functional foods and sustainable agriculture. Continued interdisciplinary research encompassing horticulture, nutrition, and food safety will further enhance their role in future food systems.

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