Tiny Greens, Big Impact: Cultivation to Conservation of Nutrient-Rich Microgreens

A. Ajay Raja
Research scholar, Department of Vegetable Science, Horticultural College and Research Institute, TNAU, Coimbatore 641 003, India
Corresponding Author: ajayraja03111999@gmail.com

Introduction

Microgreens have emerged as a trendy and potent super food in the modern dietary landscape, captivating health-conscious consumers with their extraordinary nutrient density and vibrant aesthetics. These miniature greens, harvested at an early growth stage, are rich repositories of bioactive compounds such as vitamins, minerals, antioxidants and phenolics, surpassing their mature counterparts in nutritional value. Their unique phytochemical profile not only promotes overall human health supporting immune function, reducing oxidative stress and potentially preventing chronic diseases, but also aligns with the fast-paced, health-oriented lifestyles of today's society. As a culinary delicacy and functional food, microgreens exemplify the fusion of scientific innovation and nutritional science, making them indispensable in the quest for fresh, health-boosting ingredients in a rapidly evolving world.

Microgreens differ from sprouts as they are harvested above the roots and require sunlight for growth in soil or other mediums. Microgreens need space to grow and are halfway in size between sprouts and salad mix.

Fig. 1. Different microgreens grown in tray

(Source- https://www.emmabiggs.ca/post/everything-you-need-to-know-about-growing-microgreens)

Need for Microgreens

1. Microgreens are rich in bioactive compounds like vitamins, minerals, phenolics and antioxidants, which promote health.
2. They help prevent diseases by reducing oxidative stress and inflammation.
3. Microgreens are considered functional foods with health-enhancing properties beyond basic nutrition.
4. They offer a quick, space-efficient way to enhance dietary diversity and nutritional intake.
5. Their sustainable cultivation supports food security by providing nutrient-dense produce with minimal resource use.

Cultivation Techniques and Challenges

Microgreens are emerging as a lucrative segment within the specialty produce market due to their rapid growth, high nutrient density and culinary appeal. Cultivation begins with selecting high-quality seeds, preferably untreated and pathogen-free, to ensure optimal growth and safety. The choice of crop species (e.g., mustard, basil, radish, beet, arugula) depends on market demand, growth rate and desired phytochemical profiles (Table 1).

Microgreens are typically grown in sterile, well-draining substrates such as coco peat, vermiculite, or soil mixes, which provide vital nutrients while suppressing pathogen proliferation. The growing environment demands meticulous regulation of temperature (around 18–24°C), humidity levels (approximately 50–70%) and light conditions. Interestingly, light quality significantly influences phytochemical accumulation, with blue and red spectra promoting both photosynthesis and secondary metabolite synthesis.

Growing microgreens can be conducted via various methods: traditional soil-based cultivation, hydroponics, or even soil-less media in controlled environment chambers. The latter allows for year-round production and minimizes contamination risks. The use of sustainable practices, including organic fertilizers and integrated pest management (IPM), enhances the quality and marketability of the produce.

Table 1: Bioactive compounds, harvest and storage of commonly cultivated microgreens

Microgreen	Bioactive Components / Nutrients	Harvest Stage	Storage Conditions
China Rose Radish	Total phenolics, vitamin C, antioxidants	First true leaf (~10–14 days)	Refrigerate at 2–4°C; high humidity; short shelf life of 3–5 days
Opal Basil	Vitamins A, C, flavonoids, phenolics, antioxidants	Fully expanded cotyledons and true leaves (~12–16 days)	Cold storage; breathable packaging; 4–6 days
Red Amaranth	Vitamins A, C, iron, phenolics, antioxidants	First true leaf (~12–16 days)	Refrigerate; high humidity; 4–6 days
Dijon Mustard (Brassica juncea)	Polyphenols, flavonols, anthocyanins; antioxidant compounds	About 10–14 days (first true leaves)	Refrigerate; high humidity; 3–5 days
Lettuce (various types)	Vitamins A, C, folate, carotenoids, antioxidants	10–14 days	Refrigerate; high humidity; 4–6 days
Red Cabbage	Phenolics, anthocyanins, vitamin C	First true leaf (~12–16 days)	Refrigerate; high humidity; 4–6 days
Broccoli	Glucosinolates, vitamins C, K, antioxidant compounds	10–14 days (cotyledons + true leaves)	Refrigerate; oxygen-protected; 3–5 days
Mustard (Black)	Glucosinolates, antioxidants, vitamin C	About 10–14 days	Similar to other microgreens; 3–5 days
Kale	Vitamins A, C, K, phenolics, antioxidants	12–16 days	Refrigerate; breathable packaging; 4–6 days
Table Beet	Beta-carotene, vitamin C, phenolics, antioxidants	12–16 days	Refrigerate; high humidity; 4–6 days
Celery	Vitamins C, K, phenolics, antioxidants	Around 12–16 days	Refrigerate; high humidity; 4–6 days
Buckwheat	Phenolics, flavonoids, antioxidants	5–7 days (rapid growth stage)	Keep refrigerated; short shelf life (~3–4 days)

Harvesting Precision and Postharvest Handling

Timing is critical for microgreens as are harvested at the first true leaf stage, generally between 10 to 20 days post-germination, depending on species and growth conditions. Precise harvesting ensures maximal retention of bioactive compounds, flavour and aesthetic appeal. Mechanical cutters or scissors are commonly employed to harvest microgreens just above the stem, minimizing mechanical stress that could accelerate deterioration.

Postharvest handling plays a pivotal role in extending shelf life and preserving nutritional quality. Immediately after harvesting, microgreens should be gently washed in chlorinated, sterile water to remove soil residues, followed by rapid cooling, preferably through hydro-cooling or refrigerated storage at 2–4°C to slow metabolic activity. Packaging in breathable, food-grade films with modified atmospheres such as low-oxygen, high-CO_2 environments has proven effective in delaying senescence and preserving visual quality.

Advancements in vapor emitters and anti-fogging films further enhance display stability during marketing. Attention to hygiene during postharvest processing minimizes microbial contamination, which is especially critical given the short shelf life and susceptibility to spoilage.

Market Dynamics and Strategies

The market for microgreens has experienced exponential growth driven by the rising consumer demand for nutritious, fresh and aesthetically appealing ingredients. They are primarily sold through farmers' markets, upscale grocery stores, restaurant supply chains and increasingly via online retail platforms.

To capitalize on this demand, producers must implement strategic marketing practices. Highlighting the health benefits such as high antioxidant content and functional food status through packaging and branding attracts health-conscious consumers. Emphasizing sustainable cultivation practices and organic certification can add value.

Packaging solutions must balance aesthetics, functionality and freshness preservation. Innovative designs like recyclable pouches, eco-friendly containers and clear labelling that emphasizes bioactive richness appeal to eco-conscious and health-focused buyers. Additionally, engaging in direct marketing and farm-to-table collaborations enhances consumer trust and loyalty.

Educational campaigns about the culinary versatility and health benefits of microgreens further boost market penetration. Given their perishable nature, establishing reliable cold chain logistics ensures product quality from farm to fork, enabling microgreen producers to expand into regional and national markets.

Future research prospective

- There is a great potential for growing microgreens form a variety of crops which will cater their demand in the market.
- The physiological and biochemical changes occurring during microgreen storage deserves more attention.
- Advancements of postharvest processing techniques and packaging technology will help to maintain the quality for longer periods of time and extend their shelf life.

Conclusion

Microgreens are gaining popularity due to their high concentration of antioxidants, vitamins and minerals, which are linked to good human health. A thorough understanding of crop management of microgreens and their postharvest and storage characteristics is crucial for extending their shelf life. The review provides insight which will add to the knowledge base about the management and processing of this new specialty crop.

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