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# Microgreens: The Tiny Powerhouse of Nutrition

(*Twinkle A. Tandel, Rajeshvari R. Jasani and J. M. Ganvit)
ASPEE College of Horticulture, Navsari Agricultural University, Navsari, Gujarat, India
*Corresponding Author's email: twinkletandel8110@gmail.com

Microgreens are immature greens that are harvested early which hold rewarding properties. They are considered to be rich in micronutrient composition and their phytochemical composition. microgreens have received popularity as functional foods due to their high-density nutrients and bioactive or secondary metabolite content. The morphology of microgreens is comprised of well-developed cotyledon alary leaves, immature true leaves, and a central stem. The scientific literature has documented numerous studies on microgreens such as nutritional content assessment, metabolite accumulation, nutraceutical potential, and shelf-life enhancement. Physical, chemical, biological, and cultivation factors significantly increased the microgreen's photosynthetic efficiency, growth, nutrient profile, antioxidant activity, and metabolite content. Using omics data, scientists have investigated the underlying molecular mechanism and potential gene(s) associated with nutrients, specialized metabolites, stress resistance, shelf-life enhancement, and disease resistance in nutraceutical plants.

**Keywords**: Micro-greens, bioactive compounds, cotyledons, metabolic diseases, soil-less cultivation, shelf life

## Introduction

In the 21st century world, microscale vegetables have become increasingly popular due to their high nutritional value as well as bioactive enrichment. Microgreens have received a fair share of scientific and industrial attention, particularly considering their ready-to-eat property and high nutraceutical potential. Microgreens are vegetable greens (not to be confused with sprouts or green shoots) and are harvested just after the development of cotyledonalary leaves with one set of true leaflets. In the era of global health consciousness, microgreens have been incorporated into people's diet due to their ability to fill nutritional gaps and health maintenance. Considered to be incredibly nutritious, microgreens are also known as "superfoods" and may be harvested in between a week to three weeks Microgreens are well-suited for use as salad or edible garnishes for soups, sandwiches, and a variety of main dishes due to their distinctive flavours, appealing hues, and delicate textures. The use of a different variety of microgreens species can add visual and gustatory appeal to a dish. In addition, microgreens are ideal for indoor cultivation and symbolize a global shift toward climate-controlled farming Also, the short harvesting period and high market value of microgreens make them valuable controlled environment Agri-crops.

## Microgreens, sprouts and vegetable

Microgreens are young vegetables picked between 5 and 21 days after germination, on average with height between 1 and 3 inches (average 1.5 inch). It consists of a stem, cotyledonary leaf or leaves, and two juvenile true leaves. as microgreens. The harvest time is the primary distinction between baby greens, sprouts, veggies, and micro greens. Typically, baby greens are harvested in between 20 to 40 days, while microgreens are harvested as soon

as their true leaflets were developed. The harvest time for sprouts is earlier than that of micro greens.

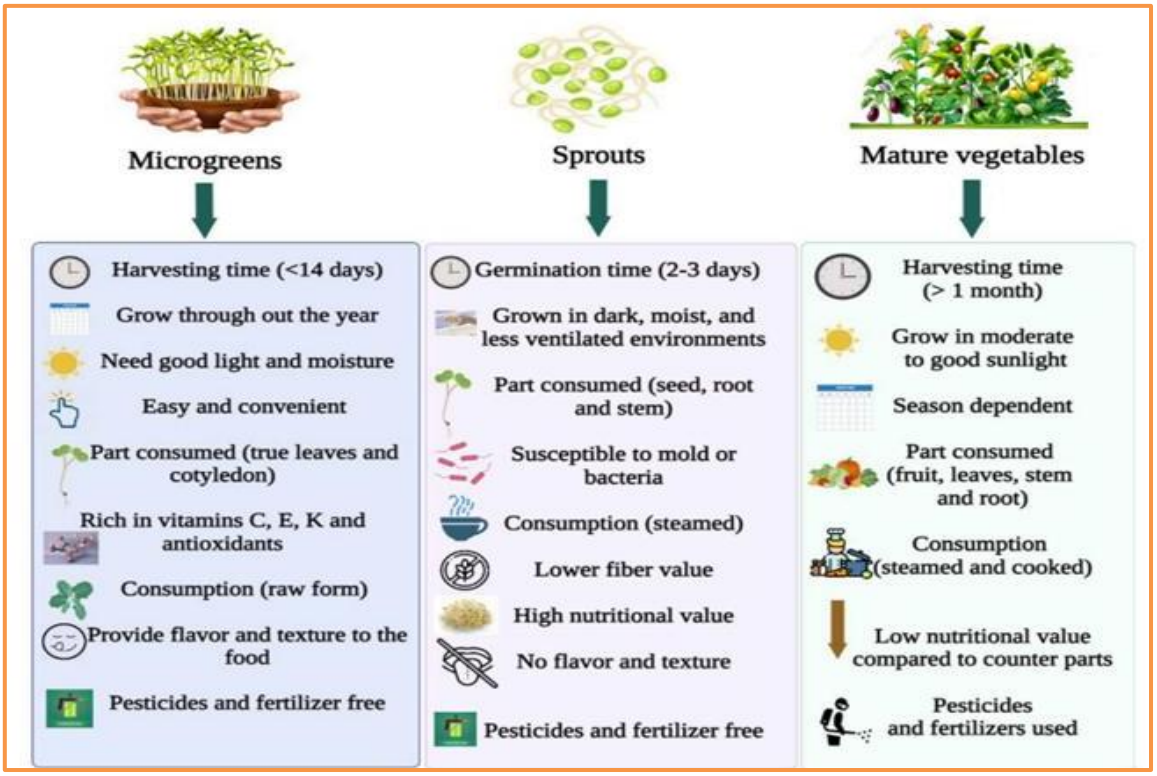


**Fig. 1**. Characteristics and properties of microgreen, spouts and matured vegetables. (https://www.biorender. com/)

## Varieties of micro greens

Microgreens can be obtained from different sorts of seeds. The well-known species are harvested using seeds from the following plant families (View & Club, 2019) :

**Brassicaceae family**: Broccoli, cauliflower, watercress, cabbage, arugula and radish
**Asteraceae family**: Endive, lettuce, radicchio, and chicory
**Apiaceae family**: Carrot, dill, celery, and fennel
**Amaryllidaceae family**: Onion, leek, and garlic
**Amaranthaceae family:** Quinoa swiss chard, amaranth, spinach, and beet
**Cucurbitaceae family**: cucumber, squash and melon

Cereals such as rice, oats, wheat, corn and barley, as well as legumes like chickpeas, beans and lentils, are also sometimes grown into micro greens. Micro greens may differ in flavour that can vary from plain to spiced, tangy or even bitter, considering type of green. Basically, their flavour is supposed to be strong and concentrated.

## Chemical composition in microgreens

In recent years, the demand of microgreens has increased due to their nutritional as well as phytochemical components. This section delivered the comprehensive discussion on vitamins, carotenoids, total sugars, minerals, and phytochemical contents in microgreens (Table 1).

**Table 1 Nutritional and phytochemical components in microgreens.**

| Micro green crops | Nutritional components | Phytochemical components |
|---|---|---|
| Amaranthus, Bottle gourd, cucumber, jute, palak, poi, pumpkin, radish and water spinach | Minerals (K, Fe, Mn, Zn and Cu) | Phenolics, flavonoids and ascorbic acid |

| | | |
|---|---|---|
| Broccoli, daikon, mustard, rocket salad, and watercress | Vitamins (E, A, K), minerals (N, K, Ca, Fe) and chlorophyll contents | Carotenoid, Isothiocyanates polyphenols, anthocyanin, monoterpene hydrocarbons, phytol and ascorbic acid |
| Buckwheat | Vitamins (B1, B2, B6, and E), proteins, minerals (Zn, Cu, Mn, Se, K, Na, Ca, Mg), starch and dietary fibre | Flavonoids, Fagopyrins, carotenoids, α-tocopherol and ascorbic acid |
| Radish | Vitamin (E), carbohydrates, protein and minerals (Ca, K and P) | Carotenoid, ascorbic acid, amino acid content, total phenols, flavonoid and anthocyanins |
| Lettuce | Minerals (Ca, Mg, Fe, Mn, Zn, Se and Mo) | Polyphenols, carotenoids and chlorophyll |
| Fenugreek | Potassium, and minerals (K, Ca, Na, Na, Cu, Fe and Cu) | Phenolic and flavonoids |

## Health promoting effects

Globally, vegetable and fruit eating habit, lowers the risk of several human diseases. Preliminary research on microgreens have emphasized on micronutrient and bioactive component enrichment. Some commonly eaten microgreens with equal or greater quantities of health promoting micronutrients have been proven to indirectly prevent chronic illnesses. Few microgreens' therapeutic benefits have been directly validated in cell and animal models, but not in clinical studies with humans. Here, we have provided the various instances of the norm.

**Anti-oxidant potential Microgreens**: Which act as dietary carriers of naturally occurring antioxidant chemicals including polyphenols and vitamins. In fact, microgreens of *Vigna radiata* and *Cicer arietinium* exhibit more antioxidant activity when compared to seeds and sprouts. Similarly, microgreens of cruciferous and umbelliferous were reported to have particularly high antioxidant capacities. Similarly, previous research tested on four genotypes of hydroponic Brassicaceae micro greens showed that soluble polyphenols and isothiocyanates were the primary contributors to the total antioxidant capacity.

**Cardiovascular disease**: Cardiovascular disease is a serious health issue worldwide due to sedentary lifestyles and poor diets, yet microgreens intake may minimise the risk. Microgreens from red cabbage have been shown to alter the lipid and cholesterol levels. The study of Huang et al. (2016) reported that red cabbage microgreen supplementation reduces weight gain, low density lipoprotein, triglycerides, and hepatic cholesterol ester levels, and liver inflammatory cytokines in mice.

**Anti-diabetic and anti-obesity activity**: Blood glucose levels in diabetic patients may be controlled by both enzymatic inhibition and improved glucose uptake. Fenugreek micro green, which contains significant amounts of polyphenols and other antioxidant chemicals, have reported antidiabetic effect at a concentration of 2 mg mL-1 by aqueous extract inhibition -amylase (70%) and increased glucose absorption in L6 cells (25%).

**Anti-cancerous activities**: According to previous research, a diet rich in fruits and vegetables may prevent cancer. Therefore, bioactive compound-rich microgreens may protect against cancer. For example, broccoli microgreens have four times more anti-cancerous aliphatic glucosinolates than its florets and mature leaves. Recent research on human colon cancer Caco-2 cells found that Brassicaceae microgreens had a significant anti proliferative impact on cancer. The antioxidants components present in Brassicaceae microgreens significantly decreased the proliferation of tumour cells by 10–12.8% (MTT assay) and 20–41.9% (Trypan-blue). It has also found that lesser, microgreens with lower ascorbic acid and antioxidant activity showed less responsive against cancer cell lines. Microgreens may regulate xenobiotic metabolism and inflammation, which may prevent cancer. The control of

multiple carcinogenic pathways is uncertain, and very few clinical studies have shown that dietary polyphenols can fight cancer. Thus, additional research is needed on microgreens' cancer preventive measures.

## Microgreens: Global status and market trends

Due to its various health benefits and nutrient-dense properties, as well as the rapid adoption of indoor farming in urban areas, the market of microgreens is on an increasing trajectory in worldwide. Globally, microgreens are gaining popularity due to their positive effects on human health and appearance, as they are 40 times more nutrient-denser than mature vegetables. As an example, broccoli appears to play a significant part in the growth of the microgreens industry due to its numerous healthy and nutritive properties. According to the report of Food and Agriculture Organization (FAO) in 2017, only China and India have produced 10.4 and 8.4 million metric tonnes of broccoli microgreen, respectively. In comparison, the United States, Spain, Mexico, and Italy collectively held less than 1 million metric tonnes. Microgreens, one of the most frequent crops grown indoors, scored 60% profitability due to high income. Also, among profitable indoor crops, microscale vegetables had the highest profit margin (40%).

## Growing conditions

In this section, different factors affecting the growth and quality of microgreens, including substrate, seed sowing density, light exposure, and cultivation strategies are discussed Different factors that affect the production of microgreen are highlighted.

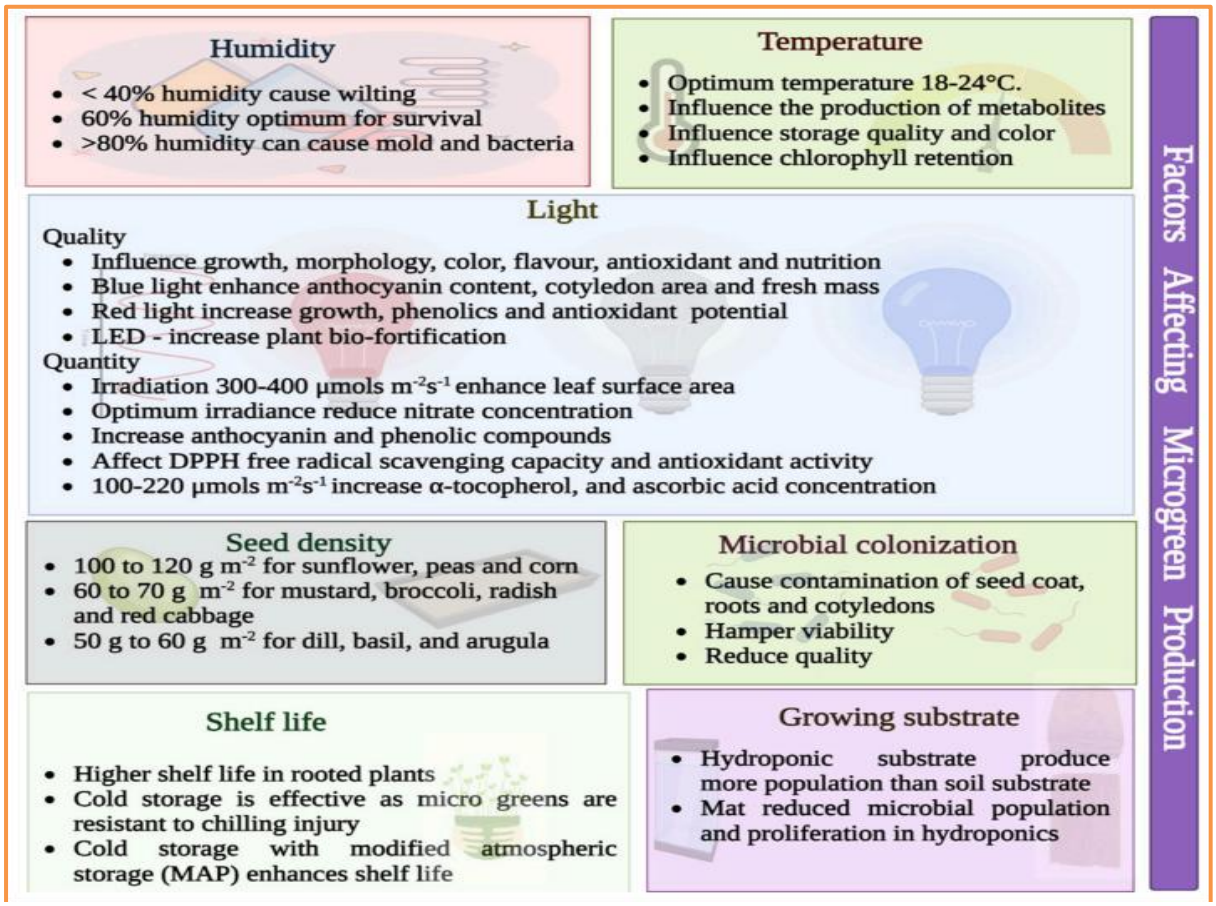


Fig. 2. Major factors (humidity, temperature, light, seed density, microbial colonization, shelf life, and growing substrate) affecting the production of microgreens (https://www.biorender.com/)

## Conclusion: challenges, possible solution, and future prospects

Like any emerging field, microgreen production faces its own set of challenges and has future directions for improvement. Here are some key challenges and future directions in microgreen cultivation. Microgreen cultivation lacks standardized practices and quality

control measures. There is a need to establish industry-wide standards for seed selection, growing media, lighting, temperature, humidity, and nutrient management. Consistent quality control will ensure uniformity in flavour, texture, and nutritional content. Microgreens are susceptible to various diseases and pests, such as damping-off, powdery mildew, and aphids. As microgreens are grown in a high-humid environment, the risk of disease and pest outbreaks is amplified. Developing sustainable and organic methods for disease and pest management will be crucial to minimize crop losses and maintain product quality. Microgreens are known for their high nutritional density. However, research is needed to optimize nutrient levels and ratios to maximize their nutritional value. Understanding the impact of different growing conditions and nutrient formulations on microgreen composition will help growers produce nutrient-rich varieties. Microgreens are typically grown in indoor environments, which require a significant amount of water and energy for lighting and climate control. Addressing the sustainability aspects of microgreen production, such as reducing water consumption and optimizing energy efficiency, will be crucial for long-term viability and environmental impact. Microgreens have a short shelf-life due to their delicate nature and high respiration rates. Improving post-harvest handling techniques, including packaging, storage, and transportation, will help extend their shelf-life and preserve their quality for consumers. Exploring new crops and introducing a wider variety of microgreens will provide consumers with more options and flavors, and expand the market potential for growers. Many consumers are still unfamiliar with microgreens and their benefits. Increasing awareness and educating consumers about the nutritional value, culinary uses, and sustainability aspects of microgreens will help drive demand and market growth. Automation and technology can play a significant role in optimizing microgreen production.

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