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Microgreens: Emerging Trends in Urban Agriculture and Nutritional Science

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Increasing desire for diets that promote longevity and health is driving an increase in interest in fresh and functional foods. In the last decade, microgreens have gained popularity as a novel culinary speciality due to their diverse range of colours, flavours, and textures. Gathered from the seeds of various species (vegetables, herbaceous plants, fragrant herbs, and wild edible plants), these young vegetables are collected a few days or weeks after germination, when the cotyledons are fully developed and the first true leaves may be emerging. They hold immense potential for enhancing the nutrient content of the human diet. The microgreens species are chosen based on agronomic and commercial criteria, distinguished by the availability of high-quality seeds, uniformity, germination potential, sanitary safety and affordability. Many species in Brassicaceae, Amaranthaceae, and other vegetables and herbs have been tested for microgreen production. Microgreens are simple to cultivate and have steadily increased in both commercial and small-scale production in urban environments because of their short development period, simple soil-less or soil-based growing methods, artificial lighting, etc. Furthermore, because of their high perishability, microgreens need to be handled carefully after harvest.

Introduction

With the global urban population boom, there is an enormous and increasing need for a more sustainable, easily available and nutrient-dense food supply. A novel class of edible vegetables, microgreens also referred as "vegetable confetti" are soft, immature greens made from the seeds of vegetables, herbs, grains and wild species (Xiao, Lester, Luo and Wang, 2012). They are typically harvested at the soil level, or at the base of hypocotyls, between 7 and 21 days after seed germination, when the first pair of true leaves appear and the cotyledons are fully expanded but still turgid. Even though both greens are eaten when still immature, microgreens and sprouts are different. Unlike micro and baby-greens, sprouts are typically produced in moisture-rich, dark environments that are favourable to microbial growth. As a result, their ingestion has been linked to foodborne illness outbreaks. Along with having a wide range of leaf colour, variation and shape, microgreens also have far stronger flavour-enhancing qualities than sprouts.

Due to their rapid growth and popularity, microgreens from different families were cultivated such as Amaranthaceae (amaranth, beet, quinoa, spinach, buckwheat, chard), Amaryllidaceae (garlic, onion, leek), Apiaceae (parsley, carrot, fennel, celery, dill, carrot, chervil, cilantro, coriander), Asteraceae (lettuce, radicchio, chicory, endive, tarragon, common dandelion), Brassicaceae (radish, watercress, arugula, broccoli, cauliflower, cabbage, chicory, wild-rocket), Convolvulaceae (water convolvulus), Cucurbitaceae (melon, cucumber, squash), Leguminosae (chickpea, alfalfa, bean, green bean, fenugreek, fava bean, lentil, pea, clover). Microgreens have different flavours. Some may taste bland, mild, spicy, bitter or even sour. In addition, oleaginous plants (sunflower), cereals (oats, soft wheat, durum wheat, corn, barley and rice), fiber plants (flax) and numerous aromatic species (like basil, chives, cilantro and cumin) are frequently utilized to grow microgreens. The microgreens species are chosen based on agronomic and commercial criteria, distinguished by the availability of high-quality seeds, uniformity, germination potential, sanitary safety and affordability.

Nutrient Profile

Since microgreens have higher concentrations of bioactive ingredients like vitamins, minerals and antioxidants than mature greens, which are crucial for human health, they are becoming increasingly popular as functional food. Microgreens provide an environmentally friendly way to improve food and nutritional security considering growing urbanization and diet-related health issues. According to recent studies, microgreens have lower nitrate contents and higher concentrations of minerals (Ca, Mg, Fe, Mn, Zn, Se, and Mo) and phytonutrients (ascorbic acid, β-carotene, α-tocopherol, and phylloquinone) than their mature-leaf counterparts. Numerous crops, including lettuce, amaranth, mustard, radish, kale, cabbage, table beets etc, can be used to grow microgreens. Compared to their fully grown counterpart, lettuce microgreens showed reduced NO_3^- and greater Ca, Mg, Fe, Mn, Zn, Se and Mo contents. Compared to microgreens, the concentration of NO_3^- in mature lettuce was four times higher. The highest concentration of vitamin C was found in red cabbage microgreens, while the highest concentration of vitamin E was found in green daikon radish microgreens. Broccoli microgreens contain nearly 50 times as much sulforaphane by weight as mature broccoli. Their exceptional nutritional potential has been emphasized by numerous research. Mung bean, lentil, radish, pearl millet, mustard, and red cabbage were assessed by Dhaka *et al*. (2023), who discovered higher levels of phenolics (55–1240 mg/100 g), anthocyanins (25–186 mg/100 g) and vitamin C (22–86 mg/100 g). Pearl millet and red cabbage stood out among them for their potent antioxidant properties. These findings support the potential of microgreens as nutrient-dense, health-promoting foods that can help those who are deficient in certain micronutrients.

Health Benefits

Consuming them has several health advantages, which includes lowering blood pressure, blood glucose, LDL cholesterol, inflammation, and obesity. Additionally, they raise haemoglobin levels, boost tumour suppression by regulating cell proliferation, and enhance liver and kidney function. Microgreens are beneficial for preventing chronic illnesses and enhancing general health because of their qualities. According to Choe, Yu and Wang (2018), microgreens are functional foods that can help prevent cancer, heart disease, obesity and type 2 diabetes.

Cultivation and Management

Microgreen production is gaining popularity due to its nutraceutical properties, which provide consumers with significant health benefits, as well as its vivid colour, robust flavour, and crisp texture. Furthermore, their rapid growth cycle makes them highly adaptable for urban and peri-urban agriculture, enabling year-round production and providing opportunities for income generation alongside improved dietary diversity. A few vital elements for successful microgreen production are species selection, seed quality, seed density, substrates, and growing methods.

Seeds

For microgreens to grow efficiently and provide their optimum yield, the germination percentage, mean seed weight, and seed quality are the primary determinants. The development of high-quality microgreens requires a significant investment in seeds, which are in high demand. Seeds should receive precautionary sanitary treatments for eliminating pathogenic bacteria. Seed priming is a straightforward, environmentally friendly, and economical technique that involves partially hydrating seeds until germination-related metabolic processes start but the radicle has not yet emerged. It is generally used to improve seed germination, plant establishment, and stress tolerance. Lee *et al.* (2004) found that matric priming improved germination and increased shoot weight by up to 2.79 times in beet and chard microgreens.

Growing Media

Depending on the production scale, microgreens can be grown in a range of conditions (indoors, outdoors or under protection) and growing systems (soil or soilless). Growing media should have a pH of 5.5–6.5, low electrical conductivity (<500 µS/cm), aeration (20–30% v/v), and a water-holding capacity of 55–70% v/v (Abad, Noguera, & Bures, 2001). Peat and peat-based media are the most often used growing media. Cocopeat is one of the most commonly used soil-less substrates for growing microgreens, owing to its affordability, widespread availability, and biodegradable nature. According to Muchjajib *et al.* (2014), the highest yield of vine spinach microgreens (5.17 kg/m2) was obtained using coconut coir dust. Although coconut coir is a renewable resource and a substitute for peat, its Physico-chemical characteristics vary, and it frequently has a high salt content as well as high bacterial and fungus counts. Polyethylene terephthalate (PET) and rockwool, two synthetic fibre materials made especially to produce microgreens, have disposal challenges. Promising yields were also found in studies that used local organic substrates, such as vermicompost and sugarcane filter cake. Natural fibre based media, such as food grade burlap constituted of recycled jute fibres, have also been developed and currently commercialized for microgreens. Additionally popular are hydroponic systems, which use nutrients and water.

Light

When growing microgreens, light is essential since it has a big impact on yield and nutritional value. Green light raised the levels of carotene, but orange light had a reverse effect. While tocopherol levels were unaltered, blue light boosted the accumulation of phytochemicals such as carotenes, lutein and chlorophyll by 1.2–4.3 times. These results demonstrate how the spectrum and intensity of light have a direct impact on the nutritional makeup of microgreens.

Contamination Risks

Because of their short growth cycle (7–21 days), microgreens are less vulnerable to pest attacks; but are more vulnerable to microbial contamination than their mature counterparts because during germination, the seeds release a mixture of peptides and sugars that draw in a variety of rhizosphere-dwelling microorganisms. However, compared to microgreens produced in soil or growing media, hydroponically grown microgreens have been found to have higher levels of microbial contamination. This could be because the hydroponic system maintains a consistent warm temperature and humid conditions.

It has been discovered that *Escherichia coli* colonizes the internal tissues as well as the surface of different microgreens. Pythium root rot, caused by *Pythium aphanidermatum* and *Pythium dissotocum*, affect the Brassicaceae family. It has been demonstrated that using bio fungicides instead of synthetic ones can boost biomass by 59% and decrease fungal infections. It has been found that applying *Trichoderma harzianum* (strain KRL-AG2 G41) and *Trichoderma virens* (strain G-41) (ThTv) to the seed ball or growth media effectively decreased damping-off (*Pythium aphanidermatum* (Edson) Fitzp.) in beetroot microgreens 14 days after planting. Good agricultural practices, such as using clean equipment, treating seeds, using UV to disinfect hydroponic systems, and using uncontaminated seeds, can readily overcome microbial contamination.

Harvesting

Depending on the species, microgreens are harvested between 7 and 21 days, when the cotyledons and true leaves were fully developed. For small-scale production, it is more practicable and economical to manually harvest seedlings above the substrate layer using scissors, removing the root part. For large-scale production, mechanical harvesting is more practical because it lowers labour costs and boosts production efficiency. However, research has shown that because microgreens are delicate and small, mechanical harvesting can also result in post-harvest damages that could affect their quality and shelf life.

Post-Harvest Handling

Cotyledons and hypocotyls combine to form microgreens, post-harvest, microgreens are extremely perishable due to high respiration rates and delicate tissues. Either by hand or by machine, they are selected, cleaned, and then packaged in plastic bags or clamshells to prevent infection. At 4 °C, the microgreens in a zip-lock PPE bag can be preserved for nine days (Arya *et al*., 2023). Shelf life is increased while preserving the nutritional and phytochemical quality by using methods like washing, drying, freezing, and chemical treatments (such citric acid, ascorbic acid, and chlorine). The ambient temperature and storage temperature have a big influence on shelf life; rapid cooling and storage at 2.5-3.5 °C are necessary to preserve freshness and extend shelf life (Kou *et al*., 2014). High respiration rates, light exposure, and poor oxygen/CO_2 balance all damage quality, so maintaining marketability and consumer appeal requires appropriate storage.

Conclusion

The increasing demand for organic food has caused interest in microgreens to increase by fourfold. Cultivation of microgreens requires minimal inputs and is suited to hydroponic and container-based systems. Essential factors include the use of high-quality seeds, sterile substrates such as coco peat or vermiculite, and proper management of light and irrigation. They are extremely versatile for urban and peri-urban agriculture because of their fast growth cycle, which allows for year-round production and offers chances for income generation in addition to enhanced dietary diversity. Overall, microgreens represent an innovative approach to sustainable agriculture and improved nutrition. Their nutrient density, adaptability, and short production cycle make them valuable in addressing hidden hunger and enhancing food system resilience. With growing consumer demand for functional foods, microgreens have significant potential to contribute to healthier diets and long-term nutritional security.

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