6 Microgreens from Vegetables: More Nutrition for Better Health

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Abstract

Microgreens are a tiny form of young edible greens which are rich in flavor and nutrition. They are rich in vitamins, particularly vitamin E, mineral (Zn), and various bioactive compounds. Plants propagated by seeds are used for microgreen production. Plants are selected for microgreens based on seedling color, texture, flavor, and local demand. Microgreens are produced in basket or pot containing growing media such as coir, bark, peat moss, perlite, rock wool, coco peat, vermiculite, vermi-compost, and sphagnum peat. Media are sterilized and treated with Trichoderma for prevention of damping-off. Microgreens are commercially produced under protected condition with natural sunlight with low humidity and good air circulation. Irrigation is the main intercultural operation for microgreen production. Microgreens are usually harvested at 7−14 days after germination in summer season and slightly longer (14–28 days) in winter season. They are a highly perishable commodity, and pre-cooling is a major postharvest operation which reduces the postharvest losses. Microgreens are consumed as raw and used in salads, sandwich, and soups.

Keywords

Microgreens · Nutrition · Bioactive compounds · Protected condition · Postharvest

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In the twenty-first century, due to poor lifestyle and food habit, the occurrence of different diseases like cancer, diabetes, obesity, cardiovascular disease, and hypertension is increasing both in developed and developing countries. Although various synthetic medicines are available to overcome these diseases, most of them are costly and have side effects. Thus, to overcome this problem, scientists are identifying newer natural sources of nutritional compound. Recently, microgreens from vegetables and other edible plants have received wide attention due to their dense source of nutrition.

Microgreens are a tiny form of young edible greens produced from various kinds of vegetables, herbs, and plants, harvested as seedling which is rich in flavor and nutrition. It has three basic parts: a central stem, two cotyledon leaves, and typically the first pair of very young true leaves which are not more than 4–14 days old depending on the species. Microgreens first became popular in the middle of 1990s in California, USA. However, the word "microgreens" was first documented in 1998. Later, it gained popularity among different upscale markets and restaurants as new culinary greens.

6.1 Why Microgreens?

Microgreens are richer sources of various micronutrients, especially vitamins and minerals. Some of the lipophilic vitamins are much higher in microgreens than mature parts. For example, vitamin E content of microgreens is up to 40 times higher compared to mature parts. Some of the recent reports reveal that some of the micronutrients like potassium and zinc are higher in microgreens. It is very interesting that antinutritional factors like nitrate and nitrite content are also low in microgreens. In addition to this, microgreens are dense sources of various bioactive compounds. Besides this, it can be easily produced using limited input, which will be useful for a person especially in urban or peri-urban settlings, where land is often a limiting factor. Furthermore, they can be produced throughout the year, since at young stages, generally the seedling does not require any specific weather condition. Given their short growth cycle, they can be grown without soil and without external inputs like fertilizers and pesticides, around or inside residential areas. Thus, they are practically chemical-free produce. Moreover, they are usually consumed raw; hence, there is no loss or degradation of thermolabile micronutrients through food processing.

6.2 Selection of Crops for Microgreen Production

Crop raised through seeds is used for microgreen production. The selection of the crop is based on seedling color, texture, flavor, and demand of the produce market. They should also have quick germination and be easily growing with high nutritive values. The most potential microgreens are found in the vegetable crops belonging to the family Amaranthaceae, Chenopodiaceae, Brassicaceae, and Apiaceae. Few crops belonging to the family Fabaceae are also suitable for microgreens (Table 6.1).

Table 6.1 Commonly used microgreens and predominant bioactive compounds

Family	Name	Scientific name	Color	Bioactive compounds
Brassicaceae	Arugula	*Eruca sativa* Mill	Green	Glucosinolates, phenolics
	Radish	*Raphanus sativus* L	Green to purplish green	Glucosinolates, phenolics, anthocyanins
	Mizuna	*Brassica rapa* L	Green	Glucosinolates, phenolics
	Pepper cress	*Lepidium bonariense* L.	Green	Glucosinolates, phenolics
	Purple knol khol	*Brassica oleracea* var. *gongylodes* L.	Purplish green	Glucosinolates, phenolics, anthocyanins
	Purple mustard	*Brassica juncea* L.	Purplish green	Glucosinolates, phenolics, anthocyanins
	Red cabbage	*Brassica oleracea* var. *capitata* L.	Purplish green	Glucosinolates, phenolics, anthocyanins
	Pak choi	*Brassica rapa* var. *chinensis* L.	Reddish green	Glucosinolates, phenolics, anthocyanins
	Tatsoi	*Brassica rapa* subsp. *narinosa* Hanelt	Reddish green	Glucosinolates, phenolics, anthocyanins
	Wasabi	*Wasabia japonica* Matsum.	Green	Glucosinolates, phenolics
	Broccoli	*Brassica oleracea* var. *italica* L.	Green	Glucosinolates, phenolics
Fabaceae	Lentil	*Lens culinaris* Medikus	Green	Phenolics, folic acid
	Pea tendrils	*Pisum sativum* L.	Green	Phenolics, folic acid
	Bengal gram	*Cicer arietinum* L.	Green	Phenolics, folic acid
	Alfalfa	*Medicago sativa* L.	Green	Phenolics, folic acid
	Methi	*Trigonella foenum-graecum* L.	Green	Phenolics, folic acid
Amaranthaceae	Amaranthus	*Amaranthus tricolor* L.	Green to red	Phenolics, betalains
Chenopodiaceae	Swiss chard	*Beta vulgaris* var. *cicla L.*	Green	Phenolics, betalains
	Palak (Fig. 6.1)	*Beta vulgaris* var. *bengalensis L.*	Green to reddish green	Phenolics, betalains
	Quinoa	Chenopodium quinoa Willd	Green to reddish green	Phenolics, betalains
	Orach	*Atriplex hortensis L.*	Red	Phenolics, betalains

(continued)

Table 6.1 (continued)

Family	Name	Scientific name	Color	Bioactive compounds
	Spinach	*Spinacia oleracea L.*	Red to reddish green	Phenolics, betalains
	Beet root	*Beta vulgaris L.*	Reddish green	Phenolics, betalains
Apiaceae	Carrot	*Daucus carota* L.	Green to purplish green	Phenolics, polyacetylene
	Coriander	*Coriandrum sativum L.*	Green	Phenolics, polyacetylene
	Celery	*Apium graveolens L.*	Green	Phenolics, polyacetylene
Poaceae	Popcorn shoots	*Zea mays L.*	Yellow	Carotenoids
Lamiaceae	Basil	*Ocimum basilicum L.*	Green to greenish purple	Phenolics
Convolvulaceae	Water spinach (Fig. 6.2)	*Ipomoea aquatica* Forssk.	Green	Phenolics
Polygonaceae	Sorrel	*Rumex acetosa L.*	Green to reddish green	Phenolics, betalains
	Buckwheat	*Fagopyrum esculentum* Moench	Green to reddish green	Phenolics, betalains

Various color shades are available in these families due to the presence of various pigments like chlorophyll, carotenoids, anthocyanin, and betalains. Chlorophyll provides lush green to deep green colors to microgreens. Carotenoids provide yellow color to microgreens. Two yellow-colored microgreens are popular in the Western market, viz. yellow popcorn shoot and yellow pea tendrils, which were achieved through etiolation. Anthocyanins provide purple coloration to microgreens belonging to families Brassicaceae and Apiaceae. Betalains mainly found in plants belonging to families Amaranthaceae and Chenopodiaceae provide vivid red-pink to yellow colors. Microgreens from Brassicaceae and Apiaceae have distinct flavor, making them suitable for garnishing various dishes. Chickpeas have sour taste, whereas fenugreek is bitter in taste.

6.3 Production Techniques

Growing media: Microgreens are produced in basket or pot containing growing media. Wide range of media are available in market such as coir, wood fiber, bark, paper fiber, peat moss, perlite, rock wool, coco peat, vermiculite, vermi-compost,

Fig. 6.1 Palak microgreens

and sphagnum peat for production of microgreens. For better growth, microgreens require a media having good physiological properties. A media with pH of 5.5–6.5, low electrical conductivity (<500 MicroS/cm), water-holding capacity of 55–70% v/v, and aeration of 20–30% v/v is ideal for microgreen production. Peat and peat-based mixes are most common media used for microgreen production. However, many countries do not have enough natural peat moss resources. In addition to this, continuous extraction of peat moss from nature may pose environmental concerns. Thus, many researchers also explore the various alternative media such as coconut coir. However, it is poor physiological and microbiological stability, presence of high salts, and high bacterial and fungal counts that make it unsuitable for microgreen production. Many inorganic materials are also explored by researchers such as perlite or vermiculite. However, their production is energy demanding and thus becomes costly for commercial production of microgreens. Some of the synthetic materials such as rock wool and polyethylene terephthalate are cheaper, but they create disposal problems. Recently, many by-products from agro-industries such as jute fiber, kenaf fiber, or cotton have been used as low-cost and renewable media for microgreen production. Research efforts have been carried out to fortify various media with suitable nutrition or beneficial microbes for quality production and prevention of pathogen growth.

Fig. 6.2 Water spinach microgreens

Before use of media, it should be treated properly to prevent the growth of microbes, which causes damping-off. Heat pasteurization is the most common way of treating growing media and is traditionally done with steam. Some media like vermiculite and perlite are inherently sterile, which do not need any sterilization. However, sterilized media are also available commercially.

Recently, hydroponic techniques are used for the production of microgreens. Research on hydroponics reveals that microgreens produced using nutrient film techniques have higher yield compared to growing on tray containing media.

Seed treatment: In addition to media sterilization, seed treatments are sometimes advised to prevent pre- or postemergence damping-off caused by soilborne pathogenic fungi (Fig. 6.3). Due to very short pre-harvest period (9–18 days), chemical treatment is avoided. Seed treatment with biocontrol agents like *Trichoderma harzianum* and *T. virens* is recommended (Fig. 6.4). In addition to treatment with biocontrol agent, other seed treatments are sometimes followed to improve,


Fig. 6.3 Damping-off in alfalfa microgreens


Fig. 6.4 Seed treatment of pea using *Trichoderma*

standardize, and shorten the production cycle (Lee et al. 2004). Seed treatment such as simple water soaking, osmo-priming, matrix priming, and seed pre-germination is carried out to enhance germination. Researchers reported priming of radish, kale, and Amaranthus seeds in fine vermiculite at 12 °C and −1.0 MPa for 3-day advanced germination (Lee and Pill 2005). Lee et al. (2004) reported that matrix priming of beet and Swiss chard advanced the greenhouse establishment of their microgreens.

Seed sowing: Seeds for microgreen production should be collected from known source. Some of the microgreens germinate easily and grow quickly like alfalfa and lentil. They require high-light condition, preferably natural sunlight with low humidity, and good air circulation. Such conditions are ideal for microgreens and do not encourage the growth of dangerous pathogens.

For commercial production, preliminary germination test is required. It helps to understand the optimal seed rate. Seed rate varies with species, germination percentage, and desired shoot population density. Excessive seed density results in microgreens with soft elongated or stretched stems and smaller leaves with shorter shelf life. Approximately 10–12 seeds per square inch for smaller seeds (for example, arugula, mustard, watercress) and 6–8 seeds for larger seeds (for example, pea, chickpea, sunflower) are good (Di Gioia and Santamaria 2015). Researchers observed that if sowing rate is increased, it increases the fresh yield per unit area. However, it decreases mean shoot weight (Murphy and pill 2010; Murphy et al. 2010).

Growing condition: Microgreens are commercially produced under protected condition. It requires high-light condition, preferably natural sunlight with low humidity, and good air circulation. Light influences morphological appearance and physiological growth of microgreens. High light levels produce a stronger, longer lasting, and more flavorful microgreens than those grown under lower light conditions or artificial lights. It also influences the biosynthetic pathways and thus under various light qualities influences the kind and quantity of phytochemicals in microgreens. For the last few decades, light-emitting diodes (LEDs) have been used for vegetable production under greenhouse. Similarly, research has initiated to use LED with deferent spectral ranges and intensity to modulate the growth of microgreens. Red spectrum light was found to keep plants short, whereas blue spectrum light fuels vegetative growth and thus encourages height. They also influence nutritional composition of microgreens. Researchers demonstrated that by altering LED spectral quality, various oxygenated (lutein, neoxanthin, violaxanthin, and zeaxanthin) and hydrocarbon (α- and β-carotene) carotenoids were enhanced in microgreens (Table 6.2). However, the enhancement varies with species and growing condition. In addition to bioactive compounds, researchers also found that LED light has a positive effect on the enhancement of minerals and vitamins. Sometimes, antinutritional compounds such as nitrate and oxalate reduced in microgreens after exposure to light-emitting diodes.

Intercultural operation: During production of microgreens, the media should be kept moist, but not overly wet. Plastic trays should be placed on benches inside a greenhouse with a sprinkler system and favorable temperature of 26 ± 2 °C. Immediately after sowing, trays should be watered and covered with an inverted slotted tray for 48 h to keep humidity levels high. The seedlings should be carefully watered twice daily and kept moist until harvesting. Generally, weeds and disease are not observed because soilless sterilized media are used and grown under protected condition. Thinning is not necessary because microgreens are grown densely.

Table 6.2 Effect of light quality on bioactive compounds of microgreens

Microgreen species	Spectral quality of light	Observation	Reference
Mustard	Supplemental green light (520 nm)	Lutein/zeaxanthin ratio and β-carotene content increased	Brazaitytė et al. (2015)
Tatsoi, red pak choi	Standard blue/red/far red (447/638 and 665/731 nm)	High levels of carotenoids	Brazaitytė et al. (2015)
Buckwheat	Blue, red, and white LED	Improved the soluble solids and vitamin C contents	Choi et al. (2015)
Amaranth, basil, mustard, spinach, broccoli, borage, beet, kale, parsley, and pea	Basal HPS lighting, supplementary red LED for 3 days before harvest	Influenced the phenolics, ascorbic acid, anthocyanin content, and antioxidant properties	Samuolienė et al. (2012)
Perilla frutescens	Supplementary red LED (638 nm) 3 days before harvest	Increased the ascorbic acid and anthocyanins and decreased nitrates	Brazaitytė et al. (2013)
Basil	Supplemental greenhouse UV-A LED lighting	Improved antioxidant activity	Vaštakaitė et al. (2015)
Broccoli	Red and blue LED light	Increased the glucosinolate content	Kopsell et al. (2014)
Beta vulgaris L.	Compound light supplemental 33% blue (445 nm)	Increased vitamin E and α- and β-carotenes, lutein, violaxanthin, and zeaxanthin content	Samuolienė et al. (2017)
Purslane	Combination of red and blue spectrum	Reduced nitrate and oxalate content	Giménez et al. (2021)

6.4 Harvesting

Microgreens are usually harvested at 7–14 days after germination in tropical climate and slightly longer (14–28 days) in cold weather or temperate region with a height of 2.5–7.6 cm (1–3 inch) that varies from crop to crop and variety to variety and other environmental conditions. These are cut along with the stem and attached cotyledons/seed leaves with the help of scissors. If left for longer, they will begin to rapidly elongate and lose color and flavor.

At the stage of harvest, sorting and delivery of good hygiene practices are important. Harvesters will need gloves and harvesting equipment such as cutters, containers, and other instruments cleansed with proprietary cleanser before and after coming into contact with the microgreens. In addition to gloves, people coming into contact with the produce should be supplied with washable or disposable clothing and hair/beard nets. This will cut down on the risk of contamination.

Postharvest operation: Microgreens are highly perishable due to their high respiration rate. After harvesting, rapid senescence gives it very short shelf life, usually 3–5 days at ambient temperature. However, under low-temperature storage condition, its shelf life may extend up to 10–14 days. Thus, proper postharvest care is essential. After harvest, microgreens are thoroughly pre-cooled, which extends the shelf life. Hydrocooling could be the cheapest method of pre-cooling for microgreens. Treatment of microgreens with NaOCl (100 mg chlorine equivalent/L, pH 6.5) at the time of hydrocooling gives additional protection from microbial contamination. After that, moisture is removed and produce is packed in a plastic container. Precautions must be taken to avoid any microbial contamination during hydrocooling. In addition to chlorine treatment, other treatments also help to extend the shelf life of microgreens. For example, Kou et al. (2015) reported that treatment of calcium lactate in chlorinated water has improved the shelf life of broccoli microgreens. In another study, Chandra et al. (2012) have reported that washing with citric acid solution with ethanol spray improved the microbiological quality of Chinese cabbage microgreens.

In recent times, macro-perforated packaging materials have been used for increasing the shelf life of microgreens. Researchers have suggested that macro-perforated low-density polyethylene self-seal bag is better for radish and Roselle microgreens than macro-perforated polythene terephthalate clamshell container. All packaging containers need labeling to show where the product came from and when it needs to be used. Applying the harvesting date is advisable. From a local grower's perspective, having a harvesting date on the pack could reinforce the freshness of the product.

Microgreens are usually consumed raw, which minimizes the loss or degradation of heat-sensitive micronutrients through food processing. Unlike cooked vegetables, there are always chances of microorganism contamination in microgreens. Thus, major emphasis should be given during production to postharvest operation.

Use: Microgreens are used in salads, sandwich, and soups. They can be used to garnish Italian and Chinese fast food. It can also be a suitable material for stuffing paratha.

References

Brazaitytė A, Jankauskiene J, Novickovas A (2013) The effects of supplementary short-term red LEDs lighting on nutritional quality of Perilla frutescens L. microgreens. Rural Dev 54–58

Brazaitytė A, Sakalauskienė S, Samuolienė G, Jankauskienė J, Viršilė A, Novičkovas A et al (2015) The effects of LED illumination spectra and intensity on carotenoid content in Brassicaceae microgreens. Food Chem 173:600–606

Chandra D, Kim JG, Kim YP (2012) Changes in microbial population and quality of microgreens treated with different sanitizers and packaging films. Hortic Environ Biotechnol 53:32–40

Choi MK, Chang MS, Eom SH, Min KS, Kang MH (2015) Physiological composition of buckwheat microgreens grown under different light conditions. J Korean Soc Food Sci Nutr 44(5): 709–715

Di Gioia F, Santamaria P (2015) Microgreens, agrobiodiversity and food security. In: Di Gioia F, Santamaria P (eds) Microgreens. Novel fresh and functional food to explore all the value of biodiversity, p 115

Giménez A, Martínez-Ballesta MDC, Egea-Gilabert C, Gómez PA, Artés-Hernández F, Pennisi G et al (2021) Combined effect of salinity and led lights on the yield and quality of purslane (Portulaca oleracea L.) microgreens. Horticulturae 7(7):180

Kopsell DA, Sams CE, Barickman TC, Morrow RC (2014) Sprouting broccoli accumulate higher concentrations of nutritionally important metabolites under narrow-band light-emitting diode lighting. J Am Soc Hortic Sci 139(4):469–477

Kou L, Yang T, Liu X, Luo Y (2015) Effects of pre-and postharvest calcium treatments on shelf life and postharvest quality of broccoli microgreens. HortScience 50(12):1801–1808

Lee JS, Pill WG (2005) Advancing greenhouse establishment of radish, kale, and amaranth microgreens through seed treatments. Hortic Environ Biotechnol 46(6):363–368

Lee JS, Pill WG, Cobb BB, Olszewski M (2004) Seed treatments to advance greenhouse establishment of beet and chard microgreens. J Hortic Sci Biotechnol 79(4):565–570

Murphy C, Pill W (2010) Cultural practices to speed the growth of microgreen arugula (roquette; Eruca vesicaria subsp. sativa). J Hortic Sci Biotechnol 85(3):171–176

Murphy CJ, Llort KF, Pill WG (2010) Factors affecting the growth of microgreen table beet. Int J Veg Sci 16(3):253–266

Samuolienė G, Brazaitytė A, Sirtautas R, Sakalauskienė S, Jankauskienė J, Duchovskis P et al (2012) The impact of supplementary short-term red led lighting on the antioxidant properties of microgreens. Acta Hortic 956:649–655

Samuolienė G, Viršilė A, Brazaitytė A, Jankauskienė J, Sakalauskienė S, Vaštakaitė V, Novičkovas A, Viškelienė A, Sasnauskas A, Duchovskis P (2017) Blue light dosage affects carotenoids and tocopherols in microgreens. Food Chem 228:50–56

Vaštakaitė V, Viršilė A, Brazaitytė A, Samuolienė G, Jankauskienė J, Sirtautas R, Duchovskis P (2015) The effect of UV-A supplemental lighting on antioxidant properties of Ocimum basilicum L. microgreens in greenhouse. In: Proceedings of the 7th International Scientific Conference Rural Development 2015. Aleksandras Stulginskis University, Akademija, pp 1–7