# MICROGREENS: TREND TOWARDS SUSTAINABLE AGRICULTURE

**Shivangi Bishnoi, Jayanti Tokas, Komal and Geeta Bishnoi**

Due to the interest of society in healthy eating over the past twenty years, there has been an increase in demand for fresh, functional, and nutraceutical foods (Ebert 2012). The recent Covid 19 pandemic caused agricultural systems to struggle with the problem of food insecurity in many regions of the world. Further, there is a higher demand for less processed and fresh greens as food offered by urban agriculture (UA) (Lal 2020). As a result, urban agriculture (UA) has recently gained a lot of attraction as it is recognised as an important tool for maintaining local food security as well as for generating income and employment in urban areas. Microgreens production is an important part of urban agriculture (Paraschivu et al. 2021; Pulighe et al. 2020). Microgreens, also called 'vegetable confetti', are tender immature greens that can be produced from the seeds of vegetables, grains or herbs, including their wild species (Xiao et al. 2012). Their popularity stems from fortified phytonutrient content, potential bioactive value and other quality attributes (such as their vivid colors, delicate textures, unique flavor enhancing properties as garnishes) (Sun et al. 2013, Xiao et al. 2015, 2012). Microgreens are the young leafy greens during cotyledon growth stage when the first couple of true leaves appear (7–14 days after sprouting, depending on the species) (Du et al. 2022). Mostly exploited species belongs to the families of Chenopodiaceae, Apiaceae, Amarillydaceae, Asteraceae, Amaranthceae, Lamiaceae, Cucurbitaceae and Brassicaceae (Andrejiova et al. 2017).

Microgreens can be produced on a big scale in industries for commercial selling, or on a small scale by individuals at home. Microgreens quality is considerably affected by their growing, harvesting and post-harvest handling (Stoleru et al. 2016). Currently, microgreens at large scale are produced in greenhouse that helps to avoid the impact of environmental pollution, making them available throughout the year (Zhang et al. 2021). Microgreens are suitable crops for indoor and greenhouse cultivation, as they require negligible input (such as fertilisers) considering their short growth period. Various soil substitutes (such as vermiculite, coconut fibre, jute fabric and peat-based media) have been explored as new growth substrates to enhance nutritional quality of microgreens and sprouts (Muchjijab et al. 2014). The suitability of these soil substitutes is determined by various attributes including their water holding capacity, bulk density, particle density, air capacity, and total pore space (Sharma et al. 2022). The effects of culture substrates on the nutritional values vary with the species of microgreens. Hydroponics is modern planting technology used widely in urban agricultural production as it could avoid the transmission of pests and diseases through the growth media to the plants. In addition, hydroponics has been applied to improve growth and nutritional content in microgreens by fertigation with nitrogen and calcium (Li et al. 2021).

## Nutritional composition

Microgreens have potential role as anti-inflammatory, anti-carcinogenic, anti-obesogenic and anti-atherosclerotic and are therefore popular as functional food of the 21$^{st}$ century (Fuente et al. 2019). The microgreens have abundant bioactive compounds such as vitamins, minerals and phytochemicals as examined in many research studies. Also, the nutritional value and phytochemicals content of vegetables and other crops may vary with plant growth and development (Zhang et al. 2021). Generally, the concentration of essential minerals, vitamins, bioactive compounds, and antioxidant activity is

Department of Biochemistry, CCS Haryana Agricultural University, Hisar, Haryana, 125004, India.
shivangi@hau.ac.in

found to be higher in microgreens as compared with their sprouted or raw seeds (Gioia et al. 2017). Examples of variations of the content of essential nutrients, vitamins, and phytochemicals are discussed below.

Kowitcharoen et al. (2021), studied the carbohydrate profile of 14 different microgreens from Brassicaceae, Pedaliaceae, Malvaceae, Fabaceae and Convolvulaceae were examined, and mungbean (7.16 g 100 $g^{-1}$) showed the highest content followed by fenugreek (5.12 g 100 $g^{-1}$). For the rest, the total carbohydrate content ranged from 2.32 to 4.90 g 100 $g^{-1}$. The protein content among 10 different microgreens ranged from 1.8 to 4.4 g per 100g (Ghoora et al. 2020). According to Paradiso's study, the protein content is higher in Brassicaceae microgreens (broccoli) in comparison to the Asteraceae (chicory) varying between 1.9 to 3.0 g per 100 g. Pajak et al. (2014) and Khang et al. (2016) showed increase in total phenolic content (TPC) and antioxidant activity of mungbean, adzuki bean, black bean, soybean, peanut, radish, broccoli and sunflower upon germination. The seed-storage compounds are broken down during the germination process leading to the synthesis of structural proteins and other cellular components (Mishra et al. 2021).

Microgreens are found to be rich in vitamins (e.g., vitamin C, tocopherol and β-Carotene), minerals (*viz.* copper and zinc), phenolic compounds and phytochemicals, which act as antioxidants in human body (Zhang et al. 2021). Ascorbic acid (vitamin C), β-Carotene (provitamin A) and tocopherols are the fat- and water-soluble vitamins that act as antioxidants protecting the cellular damage by free radicles scavenging activity (Singh et al. 2006). Phylloquinone (vitamin $K_1$), on the other hand is required for blood coagulation in the human body (Ramirez et al. 2020). Xiao et al. (2012) determined the concentrations of ascorbic acid, carotenoids, phylloquinone, and tocopherols in 25 commercially available microgreens. β-carotene levels ranged from 0.6 to 12.1 mg/100 g being highest in red sorrel (12.1 mg/100 g) and lowest in golden pea (around 0.6 mg/100 g). Red cabbage (147.0 mg/100 g) microgreens showed 6 times higher ascorbic acid content and 40 times higher tocopherol content than their mature counterpart (24.4 mg/100 g; 0.06 mg/100 g, respectively) (Singh et al., Podsedek et al. 2006). High content of α- and γ-tocopherol were detected in green radish (87.4 and 39.4 mg/100 g, respectively) while for other microgreens the range of α-tocopherol varied from 41.2 to 53.1 mg/100 g. Among the 25 microgreens assayed, the highest concentration of phylloquinone was observed in garnet amaranth (4.1 μg/g), followed by red sorrel (3.3 μg/g), green basil (3.2 μg/g), pea tendrils (3.1 μg/g), and red cabbage (2.8 μg/g) microgreens. Generally, green (pea) or bright red (amaranth) coloured microgreens were found rich in phylloquinone content were generally green (e.g., pea tendrils) or bright red in colour (*viz.* garnet amaranth microgreens), while light-coloured microgreens (golden pea) depicted relatively low concentration (Bolton-Smith et al. 2000).

Polyphenols are another group taste and color providing antioxidants in the human diet. They are found abundantly in plants as secondary metabolites. Microgreens have varied number of polyphenols varying among different species (Xiao et al. 2015). Due to the antioxidant activity microgreens can help to avoid several diseases like cancer, diabetes and heart disease (Ramirez et al. 2020). Thirteen different microgreens species representing Brassicaceae, Chenopodiaceae, Lamiaceae, Malvaceae and Apiaceae family were evaluated for phenolic content using LC–MS. Total phenolic content differed significantly across microgreens species ranging from 691 mg $kg^{-1}$ to 5920 mg $kg^{-1}$. Twenty-eight phenolic compounds were variably detected and quantitated in the 13 microgreens species examined.

Flavonol glycosides, flavones and flavone glycosides and hydroxycinnamic acids represented 67.6%, 24.8% and 7.6% of the mean total phenolic content (Kyriacou et al. 2019). Several strategies have been used to enhance phenolic content in microgreens such as the application of (Light-emitting diode) LED light, utilization of salinity stress and selenium biofortification. The transcription level of phenolic biosynthesis genes increased on illumination with blue light and UV-A for soybean microgreens (Zhang et al. 2019). Red and blue light treatment in green basil microgreens enhanced the gallic acid and rosmarinic acid content by 4 and 15 folds, respectively (Lobiuc et al. 2017). Also, phenolic acid and flavonoid in the wheat microgreen extract increased significantly by application of NaCl (12.5mM) (Islam et al. 2019). Further, selenium biofortification (16 µM) increased the total phenolic content by 21% in coriander microgreens (Pannico et al. 2020).

In mineral composition of three different microgreens chicory, lettuce and broccoli the most abundant was K and Ca followed by P and S. Lettuce microgreens had considerably higher contents of P, Ca, Mg and Zn (872 mg $kg^{-1}$, 1466 mg $kg^{-1}$, 248 mg $kg^{-1}$ and 5.2 mg $kg^{-1}$, respectively) than mature lettuce butterhead (330 mg $kg^{-1}$ P, 350 mg $kg^{-1}$ Ca, 130 mg $kg^{-1}$ Mg, and 2 mg $kg^{-1}$ Zn) (Paradiso et al. 2018). Lettuce microgreens possessed higher mineral content (Ca, Mg, Fe, Mn, Zn, Se, and Mo) and lower nitrate content than mature lettuce (Pinto et al. 2015). Although the microgreen species has higher minerals then their mature form, still some (such as Fe and Zn) are not adequate to meet the RDA value (Gude et al. 2019). Therefore, biofortification of microgreen is new trend adopted for enhanced mineral content. The biofortification (Zn and Fe) of Brassicaceae microgreens was tested on arugula, red cabbage, and red mustard microgreens. Zn content enhancement in microgreens was observed (ranging from 75% to 281%) at 5 and 10 mg $L^{-1}$ of zinc sulfate solution. On the other hand, iron enhancement (64% in arugula and 278% in red cabbage) was observed at 10 and 20 mg $L^{-1}$ of iron sulfate (Gioia et al. 2019).

## Conclusion

Microgreens are widely recognised functional foods as they are beneficial to human health due to their high levels of minerals, vitamins, polyphenols and antioxidative compounds. Several ways have been explored to enhance the nutritional content of microgreens such as biofortification (Se, Zn, Fe and others), use of different substrates (vermiculite, coconut fibre, and jute fabric) and LED light application. Hence, microgreens proved to have high research potential and help in coping with the food security and hidden hunger problem. There are still variety of wild species that need to be explored in terms of their nutritional value. Microbial contamination in microgreens is a major drawback leading to the nutrition exploitation. Several pre and post-harvest handling strategies could help to extend the shelf life of microgreens.

## References

Andrejiova A., Hegedusova A., Mezeyova I. and Konova E. 2017. Content of Selected Bioactive Substances in Dependence on Lighting in Microgreens. Acta Horticulturae et Regiotecturae, 20(1): 6-10.

Bolton-Smith C., Price R. J., Fenton S. T., Harrington D. J. and Shearer M. J. 2000. Compilation of a provisional UK database for the phylloquinone (vitamin $K_1$) content of foods. British Journal of Nutrition, 83(4): 389-399.

Du M., Xiao Z. and Luo Y. 2022. Advances and emerging trends in cultivation substrates for growing sprouts and microgreens toward safe and sustainable agriculture. Current Opinion in Food Science, 46: 100863.

Ebert A. W. 2013. Sprouts, microgreens, and edible flowers: the potential for high value specialty produce in Asia. SEAVEG 2012: High Value Vegetables in Southeast Asia: Production, Supply and Demand, 216-227.

Fuente B., Lopez-Garcia G., Manez V., Alegria A., Barbera R. and Cilla A. 2019. Evaluation of the bioaccessibility of antioxidant bioactive compounds and minerals of four genotypes of Brassicaceae microgreens. Foods, 8(7): 250.

Ghoora M. D., Babu D. R. and Srividya N. 2020. Nutrient composition, oxalate content and nutritional ranking of ten culinary microgreens. Journal of Food Composition and Analysis, 91: 103495.

Gioia F., Renna M. and Santamaria P. 2017. Sprouts, microgreens and "baby leaf" vegetables. Minimally processed refrigerated fruits and vegetables, 403-432.

Gioia F., Petropoulos S. A., Ozores-Hampton M., Morgan K. and Rosskopf E. N. 2019. Zinc and iron agronomic biofortification of Brassicaceae microgreens. Agronomy, 9(11): 677.

Gude K. M., Gioia F. Di, Pisani C., Hong J. C. and Rosskopf E. N. 2019. Variation of minerals concentration in a selection of seventeen microgreens species, Hortscience, 54: S166–S167

Islam M. Z., Park B. J. and Lee Y. T. 2019. Effect of salinity stress on bioactive compounds and antioxidant activity of wheat microgreen extract under organic cultivation conditions. International journal of biological macromolecules, 140: 631-636.

Khang D. T., Dung T. N., Elzaawely A. A. and Xuan T. D. 2016. Phenolic profiles and antioxidant activity of germinated legumes. Foods, 5(2): 27.

Kowitcharoen L., Phornvillay S., Lekkham P., Pongprasert N. and Srilaong V. (2021). Bioactive composition and nutritional profile of microgreens cultivated in Thailand. Applied Sciences, 11(17): 7981.

Kyriacou M. C., El-Nakhel C., Graziani G., Pannico A., Soteriou G. A., Giordano M. and Rouphael Y. 2019. Functional quality in novel food sources: Genotypic variation in the nutritive and phytochemical composition of thirteen microgreens species. Food chemistry, 277: 107-118.

Lal R. 2020. Home gardening and urban agriculture for advancing food and nutritional security in response to the COVID-19 pandemic. Food security, 12(4): 871-876.

Li T., Lalk G. T., Arthur J. D., Johnson M. H. and Bi G. 2021. Shoot Production and Mineral Nutrients of Five Microgreens as Affected by Hydroponic Substrate Type and Post-Emergent Fertilization. Horticulturae, 7(6): 129.

Lobiuc A., Vasilache V., Pintilie O., Stoleru T., Burducea M., Oroian M. and Zamfirache M. M. 2017. Blue and red LED illumination improves growth and bioactive compounds contents in acyanic and cyanic *Ocimum basilicum* L. microgreens. Molecules, 22(12): 2111.

Mishra G. P., Dikshit H. K., Tontang M. T., Stobdan T., Sangwan S., Aski M. and Praveen S. 2021. Diversity in phytochemical composition, antioxidant capacities, and nutrient contents among mungbean and lentil microgreens when grown at plain-altitude region (Delhi) and high-altitude region (Leh-Ladakh), India. Frontiers in Plant Science, 12: 710812.

Muchjajib U., Muchjajib S., Suknikom S. and Butsai J. 2014. Evaluation of organic media alternatives for the production of microgreens in Thailand. In XXIX International Horticultural Congress on Horticulture: Sustaining Lives, Livelihoods and Landscapes (IHC2014): 1102 (pp. 157-162).

Pajak P., Socha R., Galkowska D., Roznowski J. and Fortuna T. 2014. Phenolic profile and antioxidant activity in selected seeds and sprouts. Food chemistry, 143: 300-306.

Pannico A., El-Nakhel C., Graziani G., Kyriacou M. C., Giordano M., Soteriou G. A. and Rouphael Y. 2020. Selenium biofortification impacts the nutritive value, polyphenolic content, and bioactive constitution of variable microgreens genotypes. Antioxidants, 9(4): 272.

Paradiso V. M., Castellino M., Renna M., Gattullo C. E., Calasso M., Terzano R. and Santamaria P. (2018). Nutritional characterization and shelf-life of packaged microgreens. Food & function, 9(11): 5629-5640.

Paraschivu M. and Cotuna O. 2021. Considerations on COVID 19 impact on Agriculture and Food Security and forward-looking statements. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 21(1): 573-581.

Pinto E., Almeida A. A., Aguiar A. A. and Ferreira I. M. 2015. Comparison between the mineral profile and nitrate content of microgreens and mature lettuces. Journal of Food Composition and Analysis, 37 38-43.

Podsedek A., Sosnowska D., Redzynia M. and Anders B. 2006. Antioxidant capacity and content of Brassica oleracea dietary antioxidants. International journal of food science & technology, 41: 49-58.

Pulighe G. and Lupia F. 2020. Food first: COVID-19 outbreak and cities lockdown a booster for a wider vision on urban agriculture. Sustainability, 12(12): 5012.

Ramirez D., Abellan-Victorio A., Beretta V., Camargo A. and Moreno D. A. 2020. Functional ingredients from Brassicaceae species: Overview and perspectives. International journal of molecular sciences, 21(6): 1998.

Sharma S., Shree B., Sharma D., Kumar S., Kumar V., Sharma R. and Saini R. 2022. Vegetable microgreens: The gleam of next generation super foods, their genetic enhancement, health benefits and processing approaches. Food Research International, 11: 1038.

Singh J., Upadhyay A. K., Bahadur A., Singh B., Singh K. P. and Rai M. 2006. Antioxidant phytochemicals in cabbage (*Brassica oleracea* L.). Scientia Horticulturae, 108(3): 233-237

Stoleru T., Ionita A. and Zamfirache 2016. Microgreens—A new food product with great expectations. Romanian journal of biology, 61: 7-16.

Sun J., Xiao Z., Lin L. Z., Lester G. E., Wang Q., Harnly J. M. and Chen P. 2013. Profiling polyphenols in five Brassica species microgreens by UHPLC-PDA-ESI/HRMS n. Journal of agricultural and food chemistry, 61(46): 10960-10970.

Xiao Z., Lester G. E., Luo Y. and Wang Q. 2012. Assessment of vitamin and carotenoid concentrations of emerging food products: edible microgreens. Journal of agricultural and Food Chemistry, 60(31): 7644-7651.

Xiao Z., Lester G. E., Park E., Saftner R. A., Luo Y. and Wang Q. 2015. Evaluation and correlation of sensory attributes and chemical compositions of emerging fresh produce: Microgreens. Postharvest Biology and Technology, 110: 140-148.

Zhang X., Bian Z., Li S., Chen X. and Lu C. 2019. Comparative analysis of phenolic compound profiles, antioxidant capacities, and expressions of phenolic biosynthesis-related genes in soybean microgreens grown under different light spectra. Journal of agricultural and food chemistry, 67(49): 13577-13588.

Zhang Y., Xiao Z., Ager E., Kong L. and Tan L. 2021. Nutritional quality and health benefits of microgreens, a crop of modern agriculture. Journal of Future Foods, 1(1): 58-66.

* * * * * * * *