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The World Of Microgreens: Cultivation, Nutrition, And Health Benefits

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Abstract: A global movement toward smart agriculture is underway to help feed the world's expanding population by lowering the carbon footprint of food production and boosting food security. Global recommendations for a balanced diet have expanded from five to seven servings of vegetables per day, which has prompted efforts to find a sustainable method of producing vegetables that will both lower carbon emissions and meet consumer nutrient needs. Because they can be grown on vertical farms and have higher nutrient content than other mature crops, microgreens present an alternative that may help address issues related to the environment and human health. Microgreens are young, raw plantlets that are produced from the seeds of leafy vegetables that are edible. They can be turned into oils to produce important cosmetic goods and have a high concentration of bioactive components. Chefs are increasingly familiar with microgreens, and they are becoming more and more common at upscale supermarkets. As a result, cultivating microgreens is offering enormous global commercial potential. Growers are drawn to them because of their short production cycle, simple production methods, and nutritional advantages. They are often used as a garnish for salads, soups, and sandwiches, or as a flavourful addition to wraps and sushi rolls. Microgreens' short shelf life presents a significant obstacle to their commercialization, which is motivating research into a number of post-harvest methods. This review looks at the nutritional value and health benefits of microgreens as well as the variables that affect their growth, such as temperature, humidity, photoperiod, fertilization, and post-harvest treatments. These variables may have an impact on the growth of microorganisms, the content of phytochemicals, and the physical appearance of microgreens that are intended for market.

Keywords: Microgreens, nutritional benefits, health benefits, culinary delights

1. Introduction to Microgreens

Microscale veggies have gained popularity in recent years for use in homemade meal preparations and have drawn increased attention from the ready-to-eat market and the dietary supplement business (Galieni et al.,

2020). Microgreens are young, tender greens that are harvested at an early stage of growth, just after the first true leaves have emerged. They are characterized by their small size, vibrant colors, and intense flavors, making them a popular choice for garnishing and adding flavor and texture to a variety of dishes. Microgreens are grown from the seeds of vegetables, herbs, or grains (Delian et al., 2015). They are harvested when they are about 1-3 inches tall and produce first true leaves. These can be harvested typically within 7-21 days of sowing, depending on the variety of seed sowed. These are also known as "Vegetable confetti" (Kyriacou et al., 2016). Since lettuces are too delicate and quickly wilt, they are typically not included in the crops used to make microgreens. Microgreens have unique tastes, textures, and colors—like red or purple—that make them attractive when grown and sold. In reality, microgreens are often marketed using customized blends like as "sweet," "mild," "colourful," or "spicy". Certain microgreen plants sprout easily and thrive quickly (Verlinden, 2019). These consist of amaranth, mustard, radish, kohlrabi, mizuna, cabbage, beet. There have apparently been up to 80–100 different crops and crop kinds utilized as microgreens. Carrot, dill, arugula, cilantro, basil, onion, chive, broccoli, wheatgrass, fennel, lemongrass, popcorn, buckwheat, spinach, sweet pea, and celery are few more that have been utilized. To ascertain a crop variety's worth as microgreens, growers should assess it (Treadwell et al., 2010). Environmental factors play a crucial role in the growth of microgreens, impacting their development, flavor, and nutrient content. Some key environmental factors affecting microgreens include, photoperiod, temperature, humidity, growth medium, pH level and growth medium (Abaajeh et al., 2023).

One of the key attractions of microgreens is their high nutritional content. Despite their small size, microgreens are packed with vitamins, minerals, and antioxidants. Microgreens have shown many health benefits such as, weight management, controlling blood glucose, heart health, cardiovascular diseases etc. These have also seen good results in digestion (Zhang et al., 2021). Research has shown that microgreens can contain significantly higher levels of nutrients compared to their mature counterparts. For example, a study found that in 25 easily available microgreens, ascorbic acid, carotenoids, phylloquinone, and tocopherols ranges were higher as compared to the mature vegetables (Xiao et al., 2012). This nutrient density makes microgreens a valuable addition to a healthy diet. Similarly, the phytonutrients ascorbic acid, carotenoids, folate, α-tocopherol, and phylloquinone were found in higher concentrations in the younger leaves of baby spinach (*Spinacia oleracea L.*) than in the more mature leaves (Lester et al., 2010). Pinto et al. (2015) found that microgreens generally had higher levels of minerals compared to mature lettuces. Calcium, magnesium, potassium, and phosphorus were among the minerals that were more concentrated in microgreens. This suggests that microgreens could be a valuable source of these essential minerals, especially for individuals looking to boost their nutrient intake.

2. History and Origins

The concept of microgreens can be traced back to ancient Asian cultures in early 1980s, where they were used both for their flavour and medicinal properties. However, it wasn't until the late 20th century that microgreens gained popularity in the culinary world, thanks to their visual appeal and intense flavour

profiles. Today, microgreens are grown and enjoyed worldwide, with a wide variety of species and Flavors available to suit every palate (Choe et al., 2018).

3. Cultivation of Microgreens

Microgreens can be grown in a variety of environments, making them a versatile option for home gardeners and commercial growers alike. According to the dimension of the farm and the greater or fewer favourable climatic conditions, the commercial production of microgreens is typically carried out in a controlled environment, inside greenhouses or high tunnels equipped with either simple or advanced technologies. Soilless growing systems, which are essentially divided into three types, are used in these systems. One option is to cultivate microgreens in "containers," which are made of varying-sized plastic trays that range in height from 3 to 5 cm. growth in containers often eliminates the need to trim the product before it is transported to the market by allowing the product and growth material to be commercialized together. Another option is to cultivate microgreens in "channels" or benches (made of wood, plastic, aluminium, or galvanized iron) of varying diameters. The growth material is placed directly inside the benches or channels. The "floating system" is a third expanding system that is fairly basic but less prevalent in the commercial sphere. In this instance, nutrient solution in a basin or bench is topped off with a variety of sized polystyrene plug trays, allowing the growing media within the cells to be saturated from the bottom up (Renna et al., 2017). The cultivation process begins with selecting high-quality seeds, which are then sown densely in a shallow tray filled with a growing medium. The seeds are watered regularly and kept in a warm, well-lit environment to encourage germination. After a few days, the young seedlings begin to emerge, and they are allowed to grow for another week or two until they reach the desired size. Microgreens can be harvested on the 7-14 days depending on the variety of the sown seeds (Fig. 1) (Di Gioia et al., 2015).

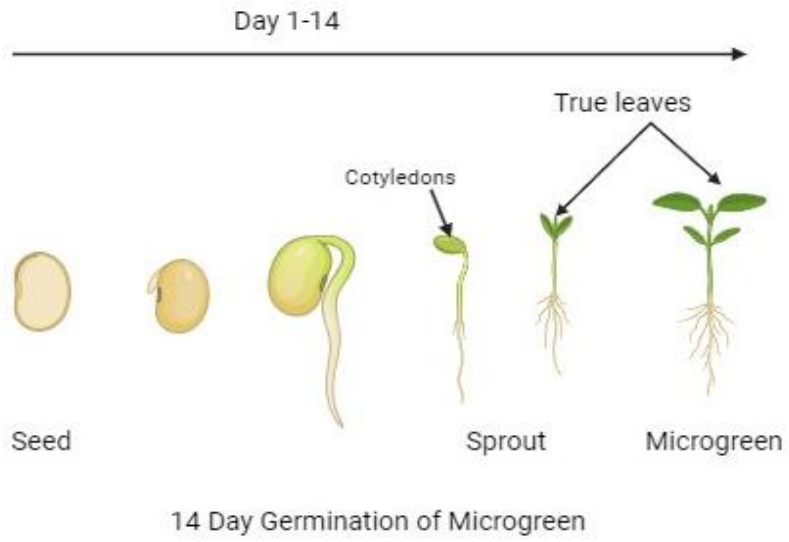

Fig.1: 14 days germination of microgreen

4. Nutritional Benefits of Microgreens

Microgreens are not only flavorful but also incredibly nutritious, making them a valuable addition to any diet. They are rich in vitamins, minerals, and antioxidants, which can help support overall health and well-being. Some studies suggest that microgreens may contain higher concentrations of certain nutrients compared to their mature counterparts, making them a potent source of nutrition (Zhang et al., 2021). Table 1 describes various nutrients and vitamins produced by different microgreens. There are many nutritional health benefits as follows:

A). Carotenoids: Carotene is an organic molecule with a reddish-orange tint that functions as a precursor to vitamin A. It is primarily found in plants with red, yellow, and orange colors. They have a significant impact on the immune system by reducing free radicals, causing cancer cells to undergo apoptosis, and increasing the generation of natural killer cells (Maurya et al., 2021). In a study, the content of β-carotene in broccoli and cauliflower microgreens was six times higher than in mature florets. It was also found that the microgreens of the Brassicaceae family are a good source of antioxidant phytochemicals, according to the results (Xiao et al., 2019). In a study conducted on twenty-five cabbage microgreens, β-carotene contents were found to vary greatly and were compared to those of the mature equivalent. Red cabbage microgreens had a β-carotene concentration that was almost 260 times higher than that of mature red cabbage (Xiao et al., 2012). In another study, the mature cauliflower has a very low carotenoid content. Simultaneously, the increased concentration of carotenoids in microcauliflower may result from the vital function of photosynthesis in the leaf tissues of microgreens; however, this may account for their little or nonexistence in cauliflower heads (Podsedek, 2005; Xiao et al., 2019). Pathan and Siddiqui, 2022 also reported presence of β -carotene in the microgreens of Quinoa

B). Ascorbic Acid: Often referred to as vitamin C, ascorbic acid is a vital bioactive phytochemical that is necessary for the body to operate. It is also regarded as an antioxidant that supports a variety of human metabolisms (Bhaswant et al., 2023). Ascorbic acid levels in the microgreens varied depending on the stage of plant growth, according to Di Bella et al. (2020). This finding raised the possibility that the ascorbic acid content in the microgreen stage of plant development was higher compared to other stages of growth, like sprouts, baby greens, and mature plants. Similar findings were reported by Ghoora et al. 2020, that the microgreen of fenugreek (*Trigonella foenum-graecum* L.), spinach (*Spinacia oleraceae* L. var.), and roselle (*Hibiscus sabdariffa* L.) have larger Vitamin C contents than their mature stages.

C). Vitamin K- Phylloquinone: Phylloquinone, the natural and active kind of vitamin K, is mostly found in fruits, vegetables, and other vegetables with green leaves (Bhaswant et al., 2023). In a study, Poorva, 2013 found that the microgreens of red cabbage, garnet amaranth, and green daikon radish have the highest concentrations of vitamins E, C, and K. Compared to mature leaves, younger leaves of baby spinach (Spinacia oleracea L.) typically contain higher amounts of carotenoids (lutein, violaxanthin, zeaxanthin, and β-carotene) and phytonutrients, such as vitamin C, Ba, and K1 (Lester et al. 2010). In another study, total 21 diversities of Brassica microgreens were analysed for different nutrient contents. It was found that

Phylloquinone, β-carotene, Total Ascorbic Acid (TAA), and α-tocopherol was higher in these varieties of Brassica microgreens (Kamal et al., 2019).

D). Vitamin E- α-Tocopherol: α-tocopherol is the most active type of vitamin E. It is a member to the vitamin E family together with β, γ, and δ tocotrienols. However, the most common kind of tocopherol found in plants is γ-tocopherol (Sadiq et al., 2019). Microgreens contain a very significant phytochemical called α-tocopherol. Numerous bodily processes depend on them, including nerve signals, muscular contractions, immune system stimulation, the prevention of free radical production, and numerous other crucial processes (Szewczyk et al., 2021; Miyazawa et al., 2019). In a study, the highest quantities of carotenoids and phylloquinone were identified in red amaranth and opal basil, respectively, whereas the highest concentrations of total ascorbic acid and tocopherols were observed in Chinese rose radish among the six studied species (Xiao et al., 2015). The microgreens from the two families (Brassicaceae and Asteraceae) that were evaluated showed higher levels of carotenoid (found in lettuce and broccoli microgreens) and α-tocopherol (found in broccoli microgreens) (Paradiso, et al., 2018).

Table 1: Various nutrients and minerals produced by different Microgreens

Microgreens	**Nutrients and Minerals produced**	**References**
Quinoa (Amaranthaceae)	tocopherols tocotrienols Different fatty acids	Pathan and Siddiqui, 2022
Amaranth	chlorophyll a and b carotenoids anthocyanins ascorbic acid	Rocchetti et al., 2020
Onion	β-carotene ascorbic acid α -tocopherols oxalic acid	Ghoora et al., 2020
Carrot	chlorophylls polyphenols anthocyanins α -tocopherols carotenoids	Paradiso et al., 2018
Radish Cucumber Jute	ascorbic acid phenolics flavonoids	Yadav et al., 2018
Red cabbage	Ascorbic acid	Sun et al., 2015

	Phylloquinone β-carotene glucobrassicin	
Broccoli	Glucoraphanin Glucobrassicin	Sun et al., 2015
Arugula	Ascorbic acid Phylloquinone β-carotene	Xiao et al., 2012

5. Health benefits of Microgreens

It is true that food has played a crucial role in the evolution of human civilization. Foods provide calories and key elements that are necessary for human survival and growth. Food served as nourishment, but it also assisted people in many cultures in preventing and treating a wide range of medical conditions (Singh et al., 2020). The development of food science and nutrition in the contemporary era is a reflection of human progress, with advances made possible by the introduction of information from disciplines like biology, medicine, and biochemistry (Minich, 2019). In addition to minimizing micronutrient deficiencies (in vitamins, minerals, etc.), the emphasis on nutrition and diet also aims to lessen the effects of chronic disorders like obesity, weight management, etc. Fig. 2 shows various health benefits of Microgreens.

A). Diabetes: Diabetes is defined by elevated blood glucose levels, which are often managed by insulin injections, strict diet plans, increased insulin sensitivity, and augmenting insulin secretion to lower blood glucose levels (Magkos et al., 2020). Microgreens, which are becoming more and more popular, are very nutrient-dense and may be quite effective in lowering diabetes. In the presence of insulin, the fenugreek microgreen extracts increased glucose absorption by 44% and inhibited α-amylase by 70% (Wadhawan et al., 2017). In a study, the grass family member barley (Hordeum vulgare) microgreen, which has different phytochemicals, enhanced glucose metabolism in male albino rats with diabetes caused by aflatoxin or streptozotocin (Khattab et al., 2022).

B). Cancer: Cancer is the second most common cause of death worldwide, after heart disease, and is a major public health concern (Siegel et al., 2021). The most common malignancies in different persons include liver, gall bladder, colon, lung, and breast cancers. It is advised that these cancer patients consume a high-nutrient diet on a regular basis of vegetables (Aune et al., 2017). Research conducted in the year 2020, the hydroponic production of four Brassicaceae microgreens (radish, broccoli, kale, and mustard) and their antiproliferative impact in colon Caco-2 cells compared to normal colon CCD18-Co cells. After giving the cells bio-accessible fractions of four microgreens for a whole day, the bioactivity of the treated cells was compared to that of 5-fluorouracil, a chemotherapy treatment used to treat colon cancer. The microgreen-treated cells displayed apoptotic cell death, reduced intracellular glutathione content, elevated reactive oxygen species, and overall cell cycle arrest in G2/M (Fuente et al., 2020).

C). Weight management: Nowadays, obesity is the major concern in each individual. In order to overcome this problem a good dietary is recommended. The model mice that were fed a high-fat diet to become obese were given broccoli microgreen juice by gavage. Melbin was used as a positive control, and it was shown to drastically reduce body weight, adipocyte size, and the amount of white adipose tissues while also increasing water consumption. It also improved glucose tolerance, reduced insulin resistance, and decreased insulin levels. These results imply that the inflammatory axis, short-chain fatty acids, lipopolysaccharides, and gut microbiota may be involved in broccoli microgreen juice's ability to prevent diet-induced obesity. Because broccoli microgreens juice increases the liver's antioxidant capacity, it can help lessen the buildup of fat in the liver. Therefore, these data suggest the intake of juice of broccoli microgreens as a nutritional supplement because of its contrary impact on obesity induced by a high-fat diet in rats (Li et al., 2021).

D). Heart health: Among other chronic diseases, cardiovascular disorders are one of the leading causes of death worldwide. A number of epidemiological research showed that eating more fruits and vegetables reduced the risk of cardiovascular illnesses (Tayyem et al., 2020). Microgreens from red cabbage have been shown to alter cholesterol and lipid levels. They used C57BL/6NCr mice that were fed a low in fat or high-fat meal with or without the addition of mature red cabbage or red cabbage microgreens for eight weeks. They discovered that red cabbage microgreen supplementation can reduce the expression of inflammatory cytokines in the liver, as well as the levels of circulating low-density lipoprotein, triglycerides, and hepatic cholesterol ester, all of which can lead to weight gain (Huang et al., 2016).

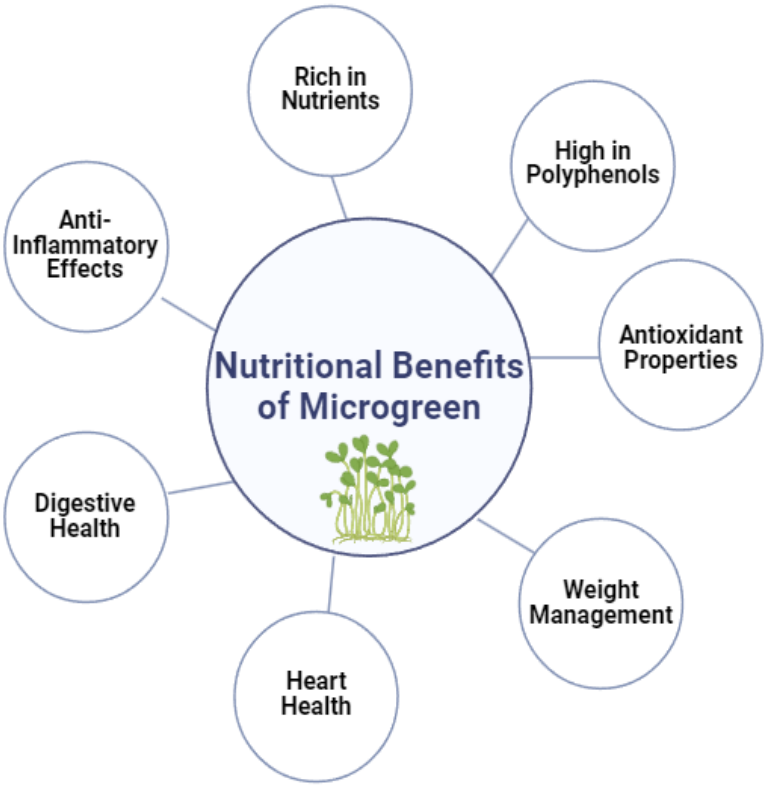

Fig.2: Nutritional and Health benefits of Microgreen

6. Culinary Uses of Microgreens

Microgreens are prized by chefs for their intense flavours and vibrant colours, which can add a burst of freshness and flavour to a wide variety of dishes. They are often used as a garnish for salads, soups, and sandwiches, or as a flavourful addition to wraps and sushi rolls. Their delicate texture and intense flavours make them a versatile ingredient that can be used in both sweet and savoury dishes. Some popular microgreens varieties include radish, broccoli, pea shoots, and sunflower shoots, each adding its unique flavour and texture to dishes (Renna et al., 2017).

7. Conclusion and Future work

Microgreens are a versatile and nutritious addition to any diet, offering a burst of flavor and a wealth of health benefits. Whether you're a home gardener looking to add some fresh greens to your meals or a chef looking to elevate your dishes, microgreens are sure to delight your taste buds and nourish your body. With their vibrant colors, intense flavors, and nutrient-packed profiles, microgreens are truly a culinary delight that deserves a place at every table. The technology used in the production of microgreens is also receiving more attention; nevertheless, there is still work to be done in the areas of packaging, shelf-life maintenance, and pre- and post-harvest processes. To ascertain the application of microgreens in general for their advantageous health-promoting qualities with evidence of mechanisms of action, more research is necessary. Research based on evidence is necessary, and there is much more to learn about the application of microgreens as personal medicine. In general, adequate knowledge of the nutritional qualities, preparation techniques, sensory attributes, and palatability of the microgreen communities should be given in order to improve health by lowering prevalent disorders.

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