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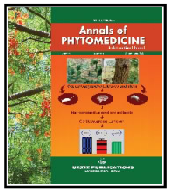

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A review on microgreens as an emerging food for health benefits

Nikhil Thakur, Anil Kumar Verma*, Jasdeep Kaur,◆, Chahat Thakur* and Aakriti**

Department of Vegetable Science, Dr. Yashwant Singh Parmar University of Horticulture and Forestry Nauni, Solan-173230, Himachal Pradesh, India

**Department of Food Science and Technology, Dr. Yashwant Singh Parmar University of Horticulture and Forestry Nauni, Solan-173230, Himachal Pradesh, India*

*** Department of Vegetable Science and Floriculture, Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishwavidyalaya, Palampur-176062, Himachal Pradesh, India*

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Abstract

Microgreens became evident specialty food product that attains quality and higher attention these days. Young foliaged greens are relished as a delicacy for its color, crunchiness and flavor. Microgreens are a novel category of wholesome vegetables which can be harvested after the emergence of primary leaves. Microgreens have fresh aroma and used as freshly made ingredients. By and large, they are used as salads and garnishing for wide variety of dishes. These microgreens have high nutritional value as it contains ample amount of antioxidants, vitamins, minerals and nourishes the human health. Generally, cultivated microgreens are peas, kale, beets, radish, sunflower and arugula. However, they ordinarily enclose a quick fundamental measure because of speedy product deterioration. On examination, microgreens and mature greens, microgreens were the richest sources of water-soluble vitamin and zinc, which are suggested to spice up the immunity of the body throughout the current state of affairs of COVID-19 threat. Hence, these could also be observed as natural supplements. This paper aims to furnish an outline of the organic process facts, their comparison with sprouts, potential bioactive compounds, and cultivation, harvesting, and promoting of microgreens at the side of their future perspective.

1. Introduction

More than the preceding 20 years, focus of functional, fresh and nutraceutical meals has been at the increase, pressured through the developing hobby of society in healthful eating. Consumers are looking for new merchandise that help fitness and sturdiness mixed with gastronomic delight (Rao *et al.*, 2021; Khan, 2021; Drewnowski and Carneros, 2000). Accordingly, it's far withinside the great hobby of forte researchers, crop growers and extension specialists to valve into upcoming tendencies and possibilities for area of interest merchandise. Microgreens are a brand new elegance of forte crop, often called 'vegetable confetti' described as gentle immature veggies constituted of the seeds of vegetables, herbs or grains, along with wild species (Xiao *et al.*, 2012). Microgreens are typically harvested on the soil level, *i.e.*, at the bottom of hypocotyls, upon the arrival of primary pair of proper leaves, while cotyledons are completely extended and turgid, typically inside 7-21 days from seed germination relying at the species (Bhatt *et al.*, 2021; Mehrotra *et al.*, 2021; Sharma *et al.*, 2021; Sun *et al.*, 2013).

The concept of microgreens originated withinside the overdue 80's in San Francisco, California, and that they have considering that received recognition as warm novel culinary elements withinside the world's best eating places and upscale grocery stores (Treadwell *et al.*, 2020). Their recognition stems from their shiny colors, sensitive textures, and specific taste improving houses as garnishes (*e.g.*, in salads, sandwiches, soups entrees, cakes and drinks), however, additionally from their fortified phytonutrient content material and ability bioactive value (Lester *et al.*, 2010). Microgreens are notably stimulated *via* way of means of rising gastronomic trends, and species choice is based on manufacturer interplay with cooks and on client familiarisation with their precise sensory attributes. Microgreens can be disbursed as fresh-reduce merchandise, however, additionally whilst developing on media, to be harvested *via* way of means of give up users. Species from the households, Brassicaceae, Asteraceae, Chenopodiaceae, Lamiaceae, Apiaceae, Amarillydaceae, Amaranthaceae, and Cucurbitaceae are the maximum typically exploited.

Microgreens are rising meals including younger fit to be eaten veggies and herbs, which can be harvested whilst cotyledonary leaves have completely evolved and the primary authentic leaves have emerged (normally 7-21 days after germination) (Allegret *et al.*, 2019). Important vegetable vegetation which might be grown as microgreens are. broccoli, cabbage, crimson cabbage, crimson amaranthus, beets, peas, radish, lettuce, chinese sarson, *etc.*

According to the 2017 Global Burden of Disease Study through the University of Washington, malnutrition changed into the pinnacle purpose of loss of life and incapacity in India in 2017. Globally, India's debts for 25.5 million youngsters out of the 50.5 million

Corresponding author: Ms. Jasdeep Kaur
Department of Vegetable Science and Floriculture, Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishwavidyalaya, Palampur-176062, Himachal Pradesh, India
E-mail: jasdeepkaur3024@gmail.com
Tel.: +91-7018302145

youngsters who're wasted globally. India has greater than one million obese youngsters (Anonymous, 2018). As consistent with the National Family Health survey (2015-2016), 51.4 consistent with cent of ladies of reproductive age are anemic. Maternal anemia has an enormous impact at the dietary repute of younger youngsters, main to stunting and underweight (Anonymous, 2015-16). Recently, the Global Hunger Index, organized through the International Institute of Food Policy, ranked India 102nd out of 117 qualifying countries. With a rating of 30.3, India suffers from a critical degree of hunger (Anonymous, 2019a).

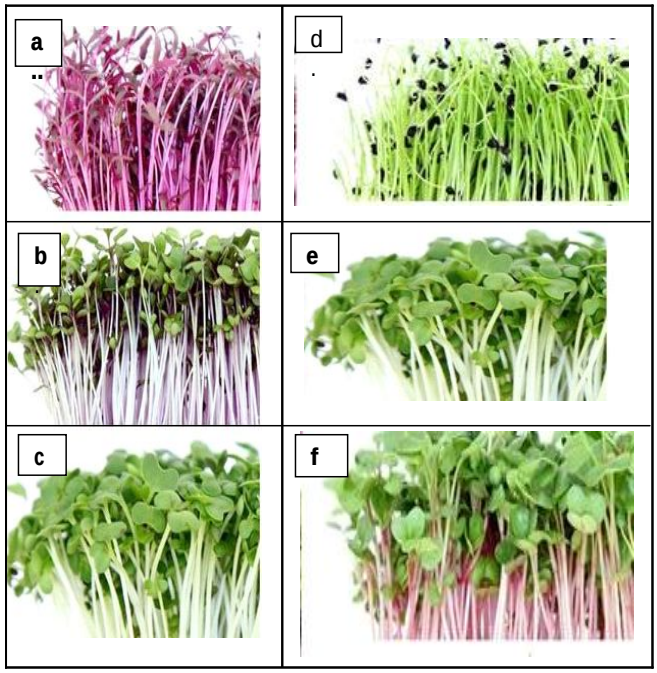

Figure 1: Microgreens of (a) Amaranthus, (b) Knol-khol, (c) Mustard, (d) Onion, (e) Pak-Choi and (f) Red radish source (Allegret *et al.*, 2019).

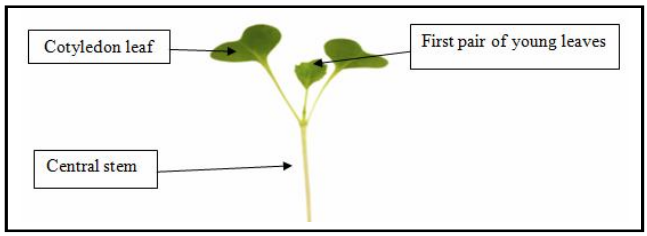

Figure 2: Different parts of microgreen plant source (Allegret *et al.*, 2019).

India is ranked a long way at the back of due to its negative overall performance in toddler losing and toddler stunting. These parameters are excessive because of malnutrition or micronutrients deficiency. The constantly developing trouble of malnutrition at international degree has elevated the call for of meals having excessive dietary value. In latest beyond we have got visible a tremendous upsurge withinside the manufacturing and productiveness of meals grains in addition to horticultural produce that's enough to feed our burgeoning populace. But now, the fundamental project earlier than us is to make sure the dietary protection *via* traditional or molecular breeding needs lengthy time. However, this may be executed in tons shorter duration via microgreens. Nowadays, non-availability of clean and pesticide residue unfastened veggies for intake is more and more turning into fundamental situation for vegetarian populace of our United States of America. So, microgreens: a brand new elegance of safe to eat veggies with masses of capacity in time period of dietary cappotential to remedy numerous deficiencies (Pinto *et al.*, 2015). These can without problems be grown in city or peri-city areas, wherein land is usually a proscribing factor, both with the aid of using specialized vegetable farmers or the customers themselves. Simultaneously, in addition they provide possibilities for rural populace of our United States of America to beautify nutritional fame in their meals.

As a unique crop, microgreens are nonetheless in relative infancy, with restricted to be had clinical statistics, however, increasing studies producing perception into their titanic capacity as wonderful foods. The gift evaluate specializes in current advances in microgreens, especially at the effect of pre-harvest factors (species selection, fertilization, biofortification, lights and harvest stage) on their body structure and quality, in addition to of postharvest factors (dealing with and applications, temperature, atmospheric composition, lights and packaging technology) on their quality, postharvest performance, and microbial safety. The evaluate concludes through figuring out primary possibilities for destiny studies aiming to beautify manufacturing efficiency, as a unique food, cultivation and dietary cost of microgreens.

2. Historical background

The history of microgreens dates back to 1930s, once wheat-grass was grown, dried and sold as a medication in most North yankee pharmacies. Within the 1960s, sunflower, buckwheat and radish were of times grown as winter greens, whereas throughout the 1970s, healthy home grown "grasses" were popularised for health benefits even chefs started growing "cresses" and "seedlings" for garnishing in the 1980s. The primary recognized use of this word "Microgreens" started in the USA in 1998. Then, in the 2000s, local

retail outlets started purchasing microgreens from native producers throughout North America. At the grocery stores, microgreens have begun to appear in order that food enthusiasts will relish their taste and flavour (Pinto *et al.*, 2015). In past few years, uptake of microgreens has accrued at the side of client responsiveness and admiration for the tender texture, unique recent flavours and targeted bioactive compounds comparable to minerals, vitamins and antioxidants then mature leaved greens.

3. Sprouts V/s microgreens

Microgreens and sprouts are various from every other. Sprouts are germinated seeds that are devoured with their entire roots. Sprouts are mop appropriately to get rid of dirt or the other reasonably hooked up foreign substances. Sprouts are typically fully grown in dark, wet saturated conditions, contributory to microbic proliferation that will result in food borne epidemics (Ebert, 2013). Soaking of seeds is done in water for diverse time and temperature, varied with different type of seeds. It will increase the moisture content in seeds and sooner or later germinates (Bergquist *et al.*, 2006; Xiao *et al.*, 2014). On alternative hand, roots are not devoured as harvesting of microgreens is done from the soil surface. Moreover, microgreens need daylight for adept growth are fully grown in soil or other medium akin to vegetable matter vermiculite, moss, and perlite (Murphy *et al.*, 2010; Xiao *et al.*, 2014). Wide selection of microgreens is obtainable for leaf color, variety, form and stronger flavor enhancing properties. In amaranth, there is substantial increase in ascorbic acid content for sprouts (8 mg/100 g) to microgreens (23.33 mg/100 g). Microgreens are grown beneath light, either in soil or soil substitutes obtained from organic or inorganic substrates. Seed density needed for microgreens is than sprouts. These conditions create microgreens less liable to microorganism contamination than sprouts (Ebert, 2013).

Table 1: Difference between sprouts, microgreen and baby-leaf/ baby greens

Features	Sprouts	Microgreens	Baby-leaf/baby-greens
Growth period (d)	4-10	7-21	20-40
Edible portion	Sprouts	Shoots (cotyledons and Ist pair of true leaves)	True leaves (no roots)
Growing method	Soilless (only water)	Mainly soilless (require some growing medium)	Soil or soilless (as growing medium)
Light requirement	No	Yes	Yes
Nutrient requirement	No	Yes (if growing medium is devoid of nutrients)	Yes
Agrochemical requirements	No	No	Yes
Harvesting (stage)	After germination but before full cotyledonary leaves stage	Generally, between full cotyledonary leaf and Ist true leaves stage	Between Ist to 8th true-leaves stage
Harvesting (cutting)	No	Yes	Yes

4. Microgreen production

4.1 Material and media

Microgreens can be grown through people for domestic use. Growing small portions domestic is noticeably easy; however, developing and advertising top-notch microgreens commercially is an awful lot greater difficulty. Having the proper blend at the suitable level for harvest is one of the maximum vital manufacturing techniques for success. The time from seeding to reap varies substantially from crop-to-crop. When seeding an aggregate of plants in a single planting flat, growers must choose plants that have a comparable boom price, so the whole flat may be harvested at once. Alternatively, growers can see the numerous plants personally and blend them after harvest (Treadwell *et al.*, 2020). Microgreens cultivation is not always very high priced as they do now no longer require an awful lot of system and cloth to grow. The choice of developing trays for business cultivation must have accurate drainage capacity. The length of developing trays may be as it should be selected relying upon the availability of area and simplicity of dealing with and transportation of residing microgreens. Inert media, together with cocopeat, vermiculite, and cocopeat alone or in a 3:1:1 ratio, must be preferred. As the idea of microgreens cultivation pertains to offering pesticide unfastened and nutritionally wealthy food, remedy with any chemical insecticides must be avoided (Kyriacou *et al.*, 2017).

4.2 Sowing

Soaking is one of critical aspect accompanied with the earlier sowing of seeds and microgreens are soaked to induce an excellent germination. Spreading of the seeds is done on the growing media and then covered with paper towel/vermiculite/cocopeat accordingly. Usually, vermiculite or cocopeat are used for larger-sized seeds and paper towel are used for smaller-sized seeds.

4.3 Aftercare

Although, microgreens do not require a great deal of challenge after the unfold of seeds, enough moisture needs to be kept thru great spray. High mild necessities of 12-sixteen hours in length need to rather be maintained alongside low humidity and true air flow for higher boom and improvement of microgreens (Kyriacou *et al.*, 2017).

4.4 Nutritional requirement

As cultivation of microgreens is intended to offer natural edibles for the advanced fitness of people, fertilizer requirements for microgreens

producing are terribly small, which will certainly be finished through natural sources. Or else, spray a solution of 10 ml $CaCl_2$, *i.e.*, 1.10 g keep with 10 litres of water (Kou *et al.*, 2013).

4.5 Harvesting

Microgreens are harvested once they obtain the first real leaf stage, generally at approximately 2 inches tall. The time from seeding to reaping can vary significantly through the crop, from 7 to 21 days. Harvesting may be completed after the advent of the first set of real leaves by slicing above the floor with scissors. Some sorts will re-develop and may be reduce numerous times. Media may be used efficiently for every other crop of microgreens. Cutting with a knife is a totally time-ingesting part of the manufacturing cycle and is regularly referred to by growers as a primary drawback. The seeding mat sort of manufacturing machine has received a reputation with many growers as it helps quicker harvesting. The mats may be picked up by hand and held vertically even as an electric-powered knife or trimmer is used for harvesting, permitting reduce microgreens to fall from the mat right into an easy harvest container. Being of perishable nature, microgreens have to be washed and cooled as quickly as possible. To enhance quality, a few cooks are asking growers to supply microgreens in trays or mats, and they may reduce the microgreens as needed (Treadwell *et al.*, 2020).

4.6 Post-harvest management

Microgreens have a brief shelf life. Hence, they require higher strategies for storage and transport. Commercial microgreens are most customarily saved in plastic clamshell boxes and refrigerated at 2.50-3.5°C for as much as 7 days. Biodegradable clamshell boxes also are to be had for packaging (Treadwell *et al.*, 2020).

4.7 Economics of microgreens

Growing microgreens is a worthwhile challenge due to its year-round production, brief developing season, and minimum investment. A 10 × 20 tray of microgreens generates a complete value of about $3-5. It enclosed the constant and variable costs, which covered the soil, water, seed, tray, strength, and packaging. The microgreen yield from a 10 × 20 tray is about 8-12 oz (227-340 g). Growers charge 25$ - 40$ according to pound for microgreens (1750-2800) and can get an income according to a tray of at least $8.5-15 (Rs. 595 - Rs. 1050) (Anonymous, 2019b).

4.8 Marketing

Microgreens, after harvesting, are directly sold to the consumer in plastic clamshell containers or can be sold as live, so they are directly harvested by the consumer to ensure the freshness of the product. Growers can target luxury hotels and restaurants.

Table 2: Benefit cost ratio of different microgreens (Source Ramya *et al.*, 2022)

S.No.	Crops	Cost of cocopeat (Rs)	Cost of seeds (OP) (Rs/kg)	Quantity of seed (g/tray)	Seed cost (Rs/quantity used)	Total cost of cultivation (Rs/ tray)	Yield (g)	Selling price of microgreens (Rs/g)	Total returns (Rs)	B:C ratio
1.	Cabbage	6.00	250.00	20.00	5.00	11.00	45.13	1.25	56.41	5:13:1
2.	Radish	6.00	240.00	20.00	4.80	10.80	53.03	1.43	75.83	7:22:1
3.	Beetroot	6.00	120.00	20.00	2.40	8.40	44.92	2.40	107.81	12:83:1
4.	Fenugreek	6.00	150.00	20.00	3.00	9.00	47.83	0.65	31.09	3:45:1
5.	Palak	6.00	200.00	20.00	4.00	10.00	40.73	0.65	26.47	2:64:1
6.	Basil	6.00	105.00	20.00	2.10	8.10	40.37	4.30	173.59	21:43:1
7.	Green gram	6.00	130.00	20.00	2.60	8.60	46.30	1.24	57.41	6:68:1
8.	Peas	6.00	120.00	20.00	2.40	8.40	40.56	0.85	34.48	4:10:1
9.	Lettuce	6.00	150.00	20.00	3.00	9.00	44.00	2.60	114.40	12:71:1
10.	Amaranthus	6.00	100.00	20.00	2.00	8.00	41.27	4.20	173.33	21:67:1

(OP) open pollinated seeds, B:C Cost, Benefit ratio.

5. Phytocomposition of microgreens

Although, a wide range of microgreens are currently being cultivated, scientific data about their direct potential to affect human physiological functions is not widely available. Nowadays, many herbs and vegetables are grown as microgreens. Brassicaceae (broccoli, cabbages, radish), Fabaceae (fenugreek, sweet pea, alfalfa), Apiaceae (carrot, parsley, celery), Asteraceae, Amaranthaceae, and many other taxonomic families are commonly cultivated. It is also well documented that the chemical composition of microgreens varies significantly from a full grown plants. There is strong evidence of a huge abundance of bioactive compounds, containing carotenoids, vitamins or minerals, glucosinolates and polyphenols (Turner *et al.*, 2020; Marchioni *et al.*, 2021).

5.1 Vitamins

Phylloquinone, recognized as vitamin K1, is highly present in the Amaranthaceae, Brassicaceae, and Lamiaceae families. The level of phylloquinone concentrations fluctuated between 0.6 to 4.1 µg/g fresh weight. Among the species, red garnet amaranth had the highest concentration (4.1 g/g fresh weight), followed by green basil (3.2 µg/g), red cabbage (2.8 µg/g fresh weight), and magenta spinach (0.9 µg/g fresh weight). Compared to mature amaranth and cabbage, phylloquinone has been detected at a lower level (0.41 to 1 fresh weight.14 µg/g fresh weight), respectively. Detailed analyses also suggested that a total of 18 out of the 25 commercially grown microgreens contain a greater amount of phylloquinone compared to their adult form (Xia *et al.*, 2012; Xia *et al.*, 2019). Besides

phylloquinone's role in blood coagulation and maintaining healthy bone tissue through the prevention of vascular calcification, it has been established, that phylloquinone also has immunosuppressive and anticancer effects (Halder *et al*., 2019). Vitamin C (total ascorbic acid) is considered as the sum of free ascorbic acid and dehydro ascorbic acid, which are highly bound in the Malvaceae, Brassicaceae, or Cucurbitaceae families. Ghoora *et al*. (2020) declare, that ascorbic acid was the most abundant in all evaluated microgreens (*e.g*., fenugreek, radish, roselle, *etc*.) with concentrations ranging from 41.6 to almost 140 mg/hundred grams.

Roselle microgreens from the Malvaceae family have the highest value of ascorbic acid, followed by basil and radish. In the previous study, Xiao *et al*. (2019) confirmed a higher level of total ascorbic acid in cauliflower and broccoli microgreens. The total ascorbic acid concentration of red cabbage, broccoli, and amaranth microgreens is 6 times greater than its mature counterpart. Ascorbic acid is a potent antioxidant, and it is also essential for a variety of human biological functions generally. In addition, it has a significant effect on collagen synthesis and immune system regulation. Severe deficiency in vitamin C could result in scurvy, and increased risks of many non-communicable diseases such as cancers, arthritis, or Alzheimer´s disease. The most active form of vitamin E is α-tocopherol. They are members of the vitamin E family, along with other tocotrienols. On the other hand, α-tocopherol is the most abundant in plants. In particular, the Brassicaceae and Apiaceae families of microgreens are considered the richest sources of them. Xiao *et al*. (2019) confirmed that green daikon radish has the greatest ã and α-tocopherols levels (mg/100 g fresh weight). In addition, pepper cress and cilantro also showed high levels of both vitamin E isoforms. According to a previous study, α-tocopherol was the most abundant in radish or sunflower (58.6 and 48.7 mg/100 g fresh weight), while mustard and spinach contain over 15-fold, respectively, 8-fold higher α-tocopherol content, compared to their mature counterparts (Ghoora *et al*., 2020). Due to the unique antioxidant properties of tocopherols have an essential role in maintaining human health due to their unique antioxidant properties. They can protect against oxidative damage in many tissues and play an important role in muscle or immune functions. At the same time, tocopherol supplementation could be the prevention of many aginge-related diseases such as cardiovascular or Alzheimer's disease (Thompson *et al*., 2020).

5.2 Minerals

Some previous studies suggest that microgreens are excellent sources of minerals. Some of them are important, but the majority is considered essential nutrients. In general, the concentrations of macro-minerals (*e.g*., potassium, magnesium, calcium, phosphorus) and trace minerals (*e.g*., manganese, zinc, sodium, and copper) are greater in 90% of microgreens cultivars compared to mature plants. The results of a recent study suggest that a valuable source with the highest concentrations of Ca, K, and Na could be the fennel microgreen. Spinach microgreens had a significantly higher content of Mg than roselle had a maximum source of P, Zn, and Se (Ghoora *et al*., 2020) Pinto *et al*. (2015) previously showed that lettuce microgreens had significantly higher concentrations of most minerals such as Ca, Fe, Zn, Mg, or Mn compared to their mature counterparts.

5.3 Polyphenols

As we have discussed previously, the nutritive and functional value of microgreens rests in their rich vitamin, mineral, sugar, and carotenoid content. However, the most important molecules essential for human health are phytochemicals that include phenolic compounds subdivided into classes such as flavonoids, phenolic acids, tannins, stilbenes, or lignans. As relatively unknown plant materials with limited scientific knowledge, the overall phenolic content, antioxidant potential, and nutritional profile of microgreens have yet to be examined. Currently, common commercial microgreens families such as Brassicaceae, Apiaceae, Lamiaceae, or Malvaceae exhibit enormous antioxidant activity with a wide variation ranging from 303.3 mmol/kg in jute to 878.3 mmol/kg in cress. Overall, the highest antioxidant capacity was confirmed in species of the Brassicaceae, followed by the Lamiaceae family. If, we look at the evidence in detail, coriander had the highest level of total polyphenol content (5920 mg/g dry weight), followed by green basil and tatsoi (3506 and 2645 mg/g dry weight). Compared to the data from mature plants (database on polyphenol content in foods), coriander has reached a level of only around 2260 mg/g in dry weight (Kyriacou *et al*., 2019). If, we look in depth, kaempferol, quercetin, isorhamnetin, and hydroxy-cinnamic acids with derivatives are the most potent health-promoting phytoconstituents commonly found in mature brassicaceous vegetables. The levels of isorhamnetin and quercetin-3-oglucoside in mature pakchoi were found to be 80-and 3-fold lower, respectively, than in microgreen counterparts. Similarly, comparing the levels of caffeic and ferulic acid, there were significantly lower values detected in mature plants. More than a 100-fold higher level of quercetin-3-O-glucoside was measured in cress, while the content of ferulic acid has been estimated at the same level, respectively. According to current evidence, microgreens have more diverse polyphenol profiles, strong antioxidant potential, and could be favored in the human diet due to their bioavailability (Kyriacou *et al*., 2019).

5.4 Glucosinolates

The last group of phytochemicals strongly abundant in microgreens is the glucosinolates. Glucosinolates are essential to plant secondary metabolites recognized as nitrogen-sulfur derivatives (α-D-thioglucoside-n-hydroxysulfates). The major group of glucosinolates are aliphatic derivates (derived from valine, isoleucine, *etc*.), followed by aromatic (derived from phenylalanine) and indole (derived from tryptophan) derivatives (Le *et. al*., 2020). Huang *et al*. (2016) compared the level of glucosinolates in microgreen red cabbage and mature plant. The results revealed a 2-fold higher concentration in microgreens (17.1 µmol/g) compared to 8.3 µmol/g in mature counterparts. Evidence about glucosinolates and their biological effects currently recognized bactericidal, nematocidal, and fungicidal properties. In addition, antioxidant, antidiabetic, and anti-inflammatory activities are well documented. Recent research also explores their modulator potential for cardiovascular, lung, and cancer diseases (Maina *et al*., 2020).

Table 3: Phytochemical concentrations between microgreens and their mature counterparts

Crops	Phytochemicals	Microgreen	Mature	References
Broccoli	Glucoraphanin	0.67–0.85 µmol/g dry weight	7.1 ± 2.5 µmol/g dry weight	Sun *et al.*, 2015; Singh *et al.*, 2006
	Glucobrassicin	10.13–10.81 µmol/g dry weight	1.1 ± 0.4 µmol/g dry weight	
Red cabbage	Total ascorbic acid	147.0 mg/100 g fresh Weight	24.4 mg/100 g fresh weight	Sun *et al.*, 2015; Singh *et al.*, 2006; Xiao *et al.*, 2012
	Phylloquinone	2.8 µg/g fresh weight	0.04 µg/g fresh weight	
	β-carotene	11.5 mg/100 g fresh weight	0.044 mg/100 g fresh weight	
	Anthocyanins	12.44 µmol/g	33.36 µmol/g	
	Glucoraphanin	4.80 µmol/g dry weight	0.88 µmol/g dry weight	
	Glucobrassicin	1.15 µmol/g dry weight	1.26 µmol/g dry weight	
Arugula	Total ascorbic acid	45.8 mg/100 g fresh weight	15.0 mg/100 g fresh weight	Xiao *et al.*, 2012
	Phylloquinone	1.6 µg/g FW	1.1 µg/g FW	
	β-carotene	7.5 mg/100 g fresh weight	1.4 mg/100 g fresh weight	

6. Health benefits of microgreens

Microgreens have superior amounts of important phytonutrients (ascorbic acid, α-carotene, α-tocopherol, and phylloquinone) and minerals (Ca, Mg, Fe, Mn, Zn, Se, and Mo) than their mature parts (Xiao *et al*., 2012). After 7 days germination in lettuce, young seedlings had the highest total phenolic concentration and antioxidant capacity in comparison to the older leaves (Oh *et al*., 2010). These polyphenols reduce the risk of atherosclerosis by inhibiting the oxidation of low-density lipoprotein (LDL) which directly prevents the risk of heart diseases, cancer and Alzheimer's disease. Microgreens have significant concentrations of glucosinolates. These are the precursors of isothiocyanate molecules that are known to induce specific pathways in mammals that block the growth of tumors (Kopsell and Sams, 2013; Fahey *et al*., 1997). Florets of broccoli (*Brassica oleracea* L. var. *italica*) are widely consumed because of their concentrated phytonutrients, especially glucosinolates (GLS). GLS have been linked to a variety of health benefits, including lower cholesterol, aiding detoxification processes, and reducing the impact of allergens (Pajak *et* al., 2014). Most notably, GLS has been linked to cancer prevention and cancer-fighting properties. The hydrolytic products of glucosinolates, isothiocyanates (ITCs) and indoles, are responsible for these anti-cancer properties by causing apoptosis of cancer cells, modulating cell cycles, suppressing inflammation, and boosting the expression of detoxifying enzymes, which reduce the carcinogenic effects of environmental toxins (Abbaoui *et al.*, 2012; Bricker *et al.*, 2014). The protective properties of GLS/ITCs, especially glucoraphanin (GLR)-glucoerucin (GLE)/sulforaphane, against chronic degenerative diseases (Barillari *et al.*, 2005; Fahey and Talalay, 1999; Nestle, 1997) have been reported. The total aliphatic glucosinolates in broccoli microgreens were around four times higher than those in mature leaves and florets (Lu *et al.*, 2018). Microgreens are considered "functional foods," food products that possess particular health promoting or disease preventing properties that are in addition to their normal nutritional values (Janovska *et al.*, 2010). However, vegetables can also be an important source of nitrate (NO_3^-) due to the use of agricultural fertilizers. NO_3^- can accumulate in plants and cause health problems (Pinto *et al.*, 2014). Nitrate is not toxic in and of itself, but approximately 5% of ingested NO_3^- is converted in the gastrointestinal tract to the more toxic nitrite anion (NO_2^-). In fact, it is the NO_3^- metabolites, *e.g.*, NO_2^- nitric oxide (NO) and N-nitroso compounds, that are considered toxic and can lead to human disorders, for example, methemoglobinemia, mainly in infants and children (Santamaria, 2006). Numerous reports have documented the development of methemoglobinemia in children after the consumption of vegetables (Sadeq *et al*., 2008; Savino *et al*., 2006; Sanchez-Echaniz *et al*., 2001). Thus, reduction of NO_3^- intake associated with vegetable consumption is advisable. Mature vegetables have higher quantities of nitrates that can be converted into nitrite in humans. This nitrite can bind to hemoglobin and prevent oxygen from being distributed through the body. Mature lettuces provide four-fold as much NO_3^- as microgreens. This means that microgreens are a good alternative for lowering NO_3^- intake while increasing intake of essential minerals (Pinto *et* al., 2015).

7. Microgreens as space food

The space missions requires the cap potential to offer suitable dietary consumption for space tourists with the least resupply from the Earth, as meals and meals packaging now constitute a sizeable burden on area undertaking consumables (Perchonok *et*

al., 2012). It is extreme for maintaining a most beneficial dietary repute for area tourists and for mitigating pressure results from long-length area travel, together with weight loss, space radiation-triggered oxidative cytotoxic pressure, oxidation of protien, hematological modifications, enlarged proteolysis of muscles, impairment of eyes and modifications in human health system (Kennedy *et. al.*, 2007; Cohu *et al.*, 2014). In addition to above, it gives a toss to the mental health and emotional stability (Rabin *et al.*, 2007). Deterrence of deleterious phenomenon that boost tissue death needs to encompass focused consumption of complete meals-primarily based totally on antioxidants incredibly than supplements (Wan *et al.*, 2006). These include sources from fresh plant, produced aboard in the course of the undertaking, thereby supplying emotional in addition to dietary help to area tourists. For instance, the intake of carotenoids *via* a complete-meals-primarily based totally food regimen is a commendable defensive degree because the human frame is not able to supply any of the foremost photoprotective carotenoids taken into consideration important for human eye vision: b-carotene as a precursor of retinal constituent diet A, and zeaxanthin and lutein for shielding the eyes with the aid of using gripping extra mild intensity. Production of bioactive compounds and mainly carotenoid-wealthy greens as a part of area lifestyles help systems (SSLSs) stays a crucial intention for destiny area missions (Perchonok *et al.*, 2012). Microgreens are of interest as cappotential meals for astronauts on long-time period missions due to the fact they have got a brief lifestyles cycle, better nutrient cost in comparison to their full-grown varieties, and may be grown in small, enclosed environments. In regenerative closed systems, microgreens are destined to supply meals, regenerate the air with the aid of using doing away with CO_2 and generating O_2, and recycle water *via* transpiration. They are best suited for the environment of flights as harvesting can be done at once with the aid of using team members, making sure freshness and excessive-quality (Kyriacou *et al.*, 2017).

Table 4: Nutritional composition of major vegetable crops as microgreens (Source Nautiyal *et al.*, 2022)

Vegetables	Protein (g)	CHO (g)	Calcium (g)	Iron (mg)	β- Carotene (µg)	Thiamine (mg)	Niacin (mg)	Riboflavin (mg)	Ascorbic acid (mg)
Cabbage	1.36	3.25	51.76	0.35	20.48	0.03	0.24	0.05	33.25
Cauliflower	3.9	3.39	96.7	2.42	146	0.05	0.21	0.05	52.8
Pea	7.2	11.8	41.06	0.71	121	0.27	1.28	0.03	38.4
Radish	0.7	6.5	30.2	0.36	-	0.02	0.3	0.02	19.9
Carrot	1.04	6.7	41.06	0.71	2706	0.04	0.25	0.03	6.76
Coriander	3.52	1.93	146	5.3	3808	0.09	0.73	0.05	23.87
Mustard leaves	3.52	2.41	191	2.84	2619	0.08	0.58	0.1	60.3
Spinach	2.14	2.05	82.29	2.95	2605	0.16	0.33	0.1	30.28
Amaranth	3.29	2.28	330	4.64	8553	0.01	0.7	0.19	83.5
Agathi	8.0	5.2	901	4.36	12582	0.26	1.18	0.33	121
Fenugreek	3.68	2.17	274	5.69	9245	0.11	0.7	0.22	58.2

8. Production and its potential

Nowadays humans are getting extra privy to the significance of microgreens. Residents in rural, city, and peri-city places can make use of the dietary ability of microgreens at domestic and market. Although, the developing method of microgreens may be very easy, the economic simple necessities of microgreens want to be considered for hit cultivation of microgreens (Kou *et al.*, 2013). North America and European nations are the essential manufacturers of microgreens. Any grain or seed may be used to provide microgreens. Different grains used for generating microgreens consist of monocotyledons and di-cotyledons. They want excessive mild levels, ideally herbal daylight with low humidity and right air circulation. 1 seed per cm^2 in big seeded which include peas and chickpeas and up to 4 seeds per cm^2 in undersized seeds like cabbage, broccoli, radish and amaranth.

9. Future prospective

Microgreens are a rising facet of the business sector, and there is smart scope for future analysis during this space because of a rise in its demand and consumption among health-conscious people. Standardization of microgreens production technologies for various crop seeds can accelerate the interest among growers. Advancements in postharvest process techniques and packaging technology will facilitate to take care of the standard for extended periods of your time and extend their shelf life. Identification of the many post-cultivation treatments has been applied time to-time-to stay quality and to increase the lifetime of microgreens. For the assembly of ready-to-eat microgreen products, laundry and drying strategies ought to be a lot of focus. It is particularly important to place more and more analysis into making certain the security and eminence of microgreens to the diets so the food business will resolve a number of the issues that have created challenges for adult vegetables.

10. Conclusion

In the decade of populace rumble, it is far critical to preserve the appropriate food plan and health. Microgreens are a current answer in a current generation to micronutrient deficiencies. Microgreens can effortlessly be integrated into your food plan in quite a few

ways. They are additionally normally very nutritious and can even lessen your chance of sure diseases. Given that they are smooth to develop at home, they are particularly low value strategies to reinforce nutrient consumption while not having to buy massive portions of veggies. Microgreens constitute a brand new elegance of veggies that may be taken into consideration as "purposeful foods" that have extra advantages past their regular dietary value. It is a key weapon withinside the combat against malnutrition because of its better attention of vitamins or pesticide residue-free. It is a capacity meal supply for astronauts due to the fact it may be freshly harvested via way of means of the astronauts themselves. It is a superb alternative for agri-commercial enterprise startups due to the fact we should develop the crop most effective for as much as 21 days. We have to attend to a brief length compared to the regular boom cycle. Hence, microgreens may be called herbal dietary supplements, and concerning them withinside the day-by-day food plan will become greater relevant, particularly in the course of gift conditions for sustainable correct health. It is specifically critical to position increasingly studies into making sure the protection and fine of this today's addition to healthful diets in order that the meals enterprise can clear up a number of the issues which have created demanding situations the absolutely grown veggies.

Conflict of interest

The authors declare no conflicts of interest relevant to this article.

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