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Microgreen -as a potential food source: A Review

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Abstract: Microgreens are immature plants without roots newly sprouted that are harvested after the development of cotyledon leaves or seed leaves. Development of cotyledon leaves done between 10 to 14 days from seedlings. Microgreens can add sweetness and spices to food. It is smaller than baby greens because they are consumed very soon after sprouting rather than after the plants have matured to produce multiple leaves. Such as immature leafy vegetables started as a food trend that was tied to high-end restaurants and their demand for an inheritance, locally collected, and unique offerings. Microgreen can provide higher amounts of phytonutrients (ascorbic acid, β-carotene, α-tocopherol, and phylloquinone) and minerals (Ca, Mg, Fe, Mn, Zn, Se, and Mo), compared with their mature- leaf counterparts. Furthermore, as the microgreens are generally consumed raw, they can also satisfy the specific needs of the so-called 'raw foodiests.' This review aims to provide data regarding Microgreen, history, production, growing media, mineral composition, and health benefits. It also includes the harvesting and packaging.

Index terms**:** Microgreen, Growing media, Sprouts, Salad, Harvest

I.INTRODUCTION

Microgreens have been defined as salad crop shoots harvested for consumption within 10 to 20 days of seedlings emergence. They are developmentally classified between "sprouts" and "baby salads" (Murphy *et al.*, 2010; Verlinden, 2020), and they are young seedlings of vegetables, herbs, or other plants, with cotyledons fully developed, and the first pair of true leaves emerged or partially expanded (Xiao *et al.*, 2015a; Verlinden, 2020). Development of cotyledon leaves done between 10 to 14 days from seedlings (Libo *et al.*, 2019). Microgreens can add sweetness and spices to food. It is smaller than baby greens because they are consumed very soon after sprouting rather than after the plants have matured to produce multiple leaves. Harvested at the first genuine leaf stage and taken with the stem, cotyledon. Sprout, Microgreen, and baby are simply those green harvested and consumed in an immature form. Sprouts are the smallest and the youngest, microgreens are slightly larger and older (usually 2 in. tall) and baby leaves are largest and the oldest (Danielle *et al.*, 2010). Microgreens have gained popularity as a new cooking trend over the last few years. Even though small in size, microgreens can provide surprisingly intense flavors, different colors, and crisp texture and can be served as a new salad ingredient or an edible garnish (Xiao *et al.*, 2012). Scientific names, family, commercial name and plant colors of the 25 commercially grown microgreens assayed in this study are listed in Table1. Some of the more popular species, subspecies, and varieties include beet, chard, and Amaranthus in the Amaranthaceae family; and mustard in the Brassicaceae family (Figure 1)(Verlinden, 2020).

Table 1. List of the various crops grown as Microgreen

Sr.No.	Scientific Name	Family	Commercial Name	Plant Color
1.	*Eruca sativa* Mill.	Brassicaceae	Arugula	Green
2.	*Beta vulgaris* L.	Chenopodiaceae	bull's blood beet	reddish-green
3.	*Apium graveolens* L.	Apiaceae	Celery	Green
4.	*Raphanus sativus* L.	Brassicaceae	China rose radish	Purplish-green
5.	*Coriandrum sativum* L.	Apiaceae	Cilantro	Green
6.	*Amaranthus hypochondriacus* L.	Amaranthaceae	Garnet amaranth	Red
7.	*Pisum sativum* L.	Fabaceae	Golden pea tendrils	Yellow
8.	*Ocimum basilicum* L.	Lamiaceae	Green basil	Green
9.	*Raphanus sativus* L. var. *longipinnatus*	Brassicaceae	Green daikon radish	Green
10.	*Spinacia oleracea* L.	Chenopodiaceae	Magenta spinach	Red
11.	*Brassica rapa* L. ssp. nipposinica	Brassicaceae	Mizuna	Green
12.	*Octimum basilicum* L.	Lamiaceae	Opal basil	Greenish-purple
13.	*Raphanus sativus* L.	Brassicaceae	Opal radish	Greenish-purple
14.	*Pisum sativum* L.	Fabaceae	Pea tendrils	Green
15.	*Lepidium bonariense* L.	Brassicaceae	Peppercress	Green
16.	*Zea mays* L.	Poaceae	Popcorn shoots	Yellow
17.	*Brassica oleracea* L.var.	Brassicaceae	Nutrient purple	Purple

Source: Xiao *et al.*, 2012

Figure 1: Microgreens can be sold as blends. This blend consists of arugula, chard, red cabbage, and sorrel. Both 4 oz (approx. 11o g) and 8 oz (approx. 220g) clamshell packages are used. Some microgreens are marketed as live plants in containers with a growing substrate, allowing chefs to harvest microgreens (Verlinden, 2020).

II. HISTORY OF MICROGREENS

The history of microgreens, such as immature leafy vegetables, started as a food trend that was tied to high–end restaurants and their demand for an inheritance, locally collected, and unique offerings (Bliss *et al.,* 2014; Verlinden, 2020). Still, immature leafy vegetables have long-lived part of our diet, the temporary rise of fresh micro produce carried over a long distance is a more recent trend. one of the most grant suppliers of micro produce in the US is a Chef's Garden, a farm that in its ongoing form has its fundamental in the 1980s (Lubow, 2006; Verlinden, 2020). Even so, microgreens are at present produced by small and large greenhouses all over the world. Since the 2000s, microgreens have been propelled into the mainstream as the interest in functional foods that support health and longevity has become significant (Kyriacou *et al.,* 2016; Verlinden, 2020). They are now Broadly promoted for production in a little scale and diversified agricultural operations (Treadwell, 2013; Alexander 2016; Verlinden, 2020). sometimes grouped with specific items such as edible flowers and sprouts (Eber, 2012; Verlinden, 2020). Many species were tested and used for the commercial production of microgreens. The majority of species and varieties used in current microgreen production belong to Amaranthaceae and Brassicaceae's Family. Some of the most popular species, subspecies, and varieties are beet, chard, and Amaranthus in the Amaranthaceae family and radish, broccoli, kale, cabbage, tatsoi, pakchoi, mizuna, arugula, and mustard in the Brassicaceae Family. Buckwheat, wheat, and rye also growing in microgreens such as grain crops. Additionally, for microgreen production, several herbs, both medicinal and cooking, have been used. Among much other borage (or starflower), parsley, basil, and fenugreek, such as consist herbs (Verlinden, 2019).

III. PRODUCTION OF MICROGREENS

For home use, microgreens may be grown by individuals. Small quantities can be relatively easy in growing at home; however, growing and marketing high-quality microgreens commercially is very challenging. One of the most critical production strategies for success is having the right mix at the perfect harvest stage. The time from seeding to harvest varies significantly from crop to crop. When seeding a mixture of crops in a single planting flat, growers should select crops with a similar growth rate so the entire flat can be harvested at once. Alternatively, growers can seed the various crops singularly and mix them after harvest. It can be grown in a standard sterile, loose, soil-less germinating media, used successfully with peat, vermiculite, perlite, coconut fiber, and another half of the tray is filled with the media of choice to a depth of ½ in. to 1or 2 in., depending on irrigation programs. Generally, overhead mist irrigation is used in this media system. Uses one of several materials as a mat or lining to be placed in the bottom of a tray or more extended through an alternative production system. Generally, these materials are fiberlike and provide an excellent seeding bed. For certain crops, the mat may be sufficient alone or may require a light topping with a media after seeding. Seeding can be done by broadcast method or in rows.

Seeding density is difficult to approve. Most growers indicate they want to seed as thickly as possible to maximize production, but not too thickly because crowding encourages elongated stems and increases disease risk. In most crops, the seed provides adequate nutrition for the young crops, requiring significantly less or no fertilizer. Light fertilization application to the tray bottom may benefit few longer-growing microgreens crops such as micro carrots, dill, and celery. Some of the faster-growing greens, such as mustard cress and chard, may also benefit from light fertilization because they quickly germinate and exhaust their self-contained nutrient supply. Light fertilization is best achieved by floating each Microgreen tray for 30 seconds in a prepared nutrient solution of approximately 80 ppm nitrogen (Libo *et al.,* 2019). Seeds can be sown on various substrates and germinated in the greenhouse on benches with overhead or sub-irrigation or germination chambers (Figure 2).

Figure 2: Supplemental light application in microgreen production with LED arrays. Two different methods of irrigation: capillary mats grow in vermiculite (Lee *et al.,* 2004 & Verlinden, 2020) or in commercially available soilless greenhouse (front) and trough culture (back) are in use (Verlinden, 2020)

IV. GROWING MEDIA

Microgreens can be grown in several media. Some growers prefer perlite (Johnson 2012 & Verlinden, 2020), while others mixes (Gioia *et al.,* 2016; Verlinden, 2020). Most growers prefer peat-based mixes or synthetic mats, and early growth on filter paper has been used in experimental settings to study additions to the germination media such as spent brewer's yeast (Lobiuc *et al.,* 2017; Verlinden, 2020). Composts mixed with sand and vermiculite have also been evaluated (Anon, 2016 & Verlinden, 2020)(16) and sand, peat, coconut coir dust sugarcane filter cake, and Vermicompost in several rations. All were effective in producing microgreens (Muchjijab *et al.,* 2015). From Handy Pantry, All growing and insert trays, humidity domes, and micro-mat Hydroponic Growing pads used for growing Microgreen were obtained. Five grams of broccoli seed was sowed in each of 15,5"× 5" insert trays containing Vermicompost or micro-mat Hydroponic Growing Pads. The seeds in five insert trays containing Vermicompost and five insert trays containing hydroponic growing pads were hydrated with sterile deionized water during the experiments (Weber, 2017). Microgreen of Brassicaceae Family, Kohlrabi, Mustard, Red pak choi, Tatsoi, Basil and Parsley were grown in peat substrate in 0.5 L Plastic Vessels for 10 to 19 days from sowing to harvest (Samuoliene *et al.,* 2013). The following amounts of nutrients were available in the substrate: N 110, P_2O_5 50, K_2O 160 (used as mg L^{-1}); microelements- Fe, Mn, Cu, B, Mo, Zn (used as mg L^{-1}). Depending on size and weight, 1 g of basil and 2 g of parsley seeds were seeded per vessel. Depending on the size and weight of seeds were seeded per vessel, experiments were performed in controlled-environment growth chambers. Day/Night temperatures of 21/17 2° C were established with a 16 h photoperiod and a relative air humidity 50- 60% (Samuoliene *et al.,* 2016). And hydroponics microgreens were grown in a floating hydroponic system. Seeds were sown in polystyrene cell trays filled with vermiculite. Seed germination occurred in a climate chamber in the dark at 24°C. After two days from sowing, rocket seeds germinated, while three days were necessary for basil and Swiss chard germination. After Germination, trays were transferred in a polyethylene (PE) tank (30/60/6.5cm^3) containing each 5 L of half-strength Hoagland nutrient solution. Initial pH: 5.56, initial electric conductivity: 1.12ms cm^{-1} prepared with distilled water (Bulgari *et al.,* 2017).

V. MINERAL COMPOSITION AND HEALTH BENEFITS

Microgreen can provide higher amounts of phytonutrients (ascorbic acid, β-carotene, α-tocopherol, and phylloquinone) and minerals (Ca, Mg, Fe, Mn, Zn, Se, and Mo), compared with their mature- leaf counterparts. Their distinctive peculiarities, microgreens represent a rich food source for particularly demanding categories of consumers, like vegetarians and vegans, who can diversify and enrich their diet using a large variety of available microgreens. Furthermore, as the microgreens are generally consumed raw, they can also satisfy the specific needs of the so-called 'raw foodiests'(Renna *et al.,* 2018). Essential minerals elements are a class of nutritionally essential nutrients for human health, which are best obtained from dietary sources. Elements are divided into two groups: the macro elements (such as Ca, Mg, P, K, and Na) and microelements (also Known as trace elements, such as Fe, Zn, Cu, and Mn), both of which play crucial roles in various biological processes for both plants and the human beings. Deficiencies in these elements can cause metabolic disorders and organ damage, leading to acute and chronic diseases and even death for humans. For example, the importance of calcium and vitamin D on bone mass and bone metabolism is well known, and studies have shown that adequate intake of magnesium and potassium from a healthy diet could contribute to optimizing bone health, while deficiencies in these elements can cause dwarfism in children osteoporosis in the elderly. Sufficient dietary intake of mineral elements is necessary for human health and wellness. For human nutrition, unfortunately; minerals malnutrition is still a common problem worldwide and considered one of the most critical global challenges (Xiao *et al.,* 2016).

VI. LIGHT EFFECT

For plants, light is one of the most important environment factors, as it provides the source of energy for photosynthesis and the signal for a multitude of physiological response. Light quality (Wavelength), light quality (intensity), direction, and photoperiod (duration) are vital components of light conditions. The use of artificial light sources (e.g. fluorescent lamps, halogen light, LED light and high-pressure sodium lamp), which emit photons over a spectral range from 250nm to 750 nm, make the study of effects of light on the nutrients quality of sprouts and microgreens more convenient and the results more conclusive (Xiaoyan Zhang et al., 2020)(24). The light environment plays a significant role in influencing physiological change and secondary metabolite production in plants. It can affect growth and nutrition variation in both the artificial lighting spectra and irradiance levels. Light-emitting diodes (LEDs) are, to date, one of the most promising energy-efficient and rapidly developing plant light technologies. For sprouted seed, Microgreen, wheatgrass and mature lettuce plant cultivation, combinations of red, blue and far-red LED light wavelengths are reported to be efficient. In plant, during production the objective of the current study was to examine the effects of light intensity produced by LED on the growth and antioxidant properties of microgreens from the Brassicaceae family and to determine lighting conditions needed to induce higher nutritional values. In controlled- environment growth chamber was performed experiments (Samuoliene *et., al*, 2013).

The effect of light levels and light quality differs by species and sometimes by variety. For example, green light can enhance carotenoid accumulation in mustard microgreens, but red pak choi and tatsoi accumulate carotenoids under blue, red, and far-red illumination (Brazaityte *et al.*, 2015a).

VII. HARVEST& POSTHARVEST

The first appearance of the first true-leaves, 11 days after sowing, microgreens of each tray were harvested by cutting the seedling just above the growing media's surface with a sterilized knife. Harvested microgreens were weighed to determine fresh shoot weight (FW) per unit area (Gioia *et al.*, 2016). Most species are harvested at the first true leaves' appearance, with cotyledons fully expanded, still turgid, retaining their typical color, and seedlings having a height of 5-10 cm. Harvest is performed by cutting the seedlings manually or mechanically few millimeters above the growing media surface. Particular attention should be placed to exclude growing media particles and seed integuments, which in some species remain attached to the cotyledons (Kyriacou *et al.*, 2016). Whereas sprouts are mainly soaked in the water and younger, with the cotyledon not opened or just opened. With the increasing consumption of microgreens, concern over a situation similar to the sprout boom occurs (Wang & Kniel, 2016). For the expansion of commercial microgreens production, postharvest perishability is arguably the most limiting factor. They require careful, often tedious harvesting and quick cooling to remove vital heat and suppress the rate of respiration, spoilage and senescence. Harvesting microgreens is labor-intensive and can directly impact production cost, primarily when production is implemented in trays that require harvesting with scissors. Use of loose substrate in trays slows down the harvesting process, whereas seeding on synthetic fiber, food-grade plastic, or burlap-type mats can facilitate easier handling and faster harvesting and cooling of the product (Treadwell *et al.*, 2010). However, recommendations limiting the introduction of pathogens through seed or irrigation water contamination should be similar to those for sprouts production (Xiao *et al.*, 2014c; Reed *et al.*, 2018; Wright & Holden 2018; Verlinden, 2020). The use of blunt blades has been shown to reduce the storage life of fresh-cut leafy vegetables, and harvesting microgreens must likewise be performed with sharp blades to avoid bruising and damage to stem cells adjacent to the cut (Portella & Cantwell, 2001; Kyriacou *et al.*, 2016). Humidity control and insect exclusion are essential to successful microgreen production. Harvesting is often done by hand (Figure 3).

Figure 3: Hand harvesting of arugula (*Eruca sativa*) into a holding tray followed by packaging in plastic bags for the wholesale market (Verlinden, 2020)

VIII. TEMPERATURE & STORAGE

Microgreens are delicate and have a concise shelf life (1-2 days) at ambient temperatures, and are categorized as highly perishable products. Storage the temperature is some of the most critical factors affecting the postharvest physiology and storage behavior of produce. In general, low-temperature storage can reduce quality loss and extend shelf life by depressing respiration rates, senescence, and growth of spoilage microgreen. Optimum storage temperature varies depending on the fruit or vegetable. Low-temperature storage adversely affects quality attributes and causes deterioration more rapidly for some chilling sensitive fruits and vegetables. Thus, The selection of optimum storage temperature is crucial (Xiao et al., 2013). Microgreen used for temperature studies were packaged (10g/bag) unwashed in polyethylene bags (15cm × 15cm) with film OTRs of 8.0, 16.6, 21.4 and 29.5 pmol/ (m^2s Pa) and stored at 5˚C for 21 days with evaluations performed on days 0,4,7,14 and 21 (Kou *et al.*, 2012).

IX. PACKAGING

Modified atmosphere packaging (MAP) is an effective technology for maintaining freshness and prolonging the shelf life of produce, which has been successfully applied in fresh and minimally processed produce, such as Lettuce, Broccoli, Spinach and Mushrooms.

Many factors are influencing the package atmosphere of products, including product respiration rate, packaging film Oxygen Transmission Rate (OTR), product weight, packaging surface area, storage temperature and relative humidity (Sandhya, 2010).

X. CONCLUSION

Microgreens gather immense potential for adapting leafy vegetables production to a micro- scale, improving nutritional value in the human diet, and influencing gastronomical trends. Progress in understanding storage& temperature and Preharvest factors affecting their production and quality and postharvest factors commanding shelf-life have been examined in the current review, along with challenges lying ahead. The determination of mineral elements by ICP OES provided a satisfactory quantification of Ca, Mg, P, K, Na, Fe, Zn, Mn, and Cu in 30 different microgreens in the Brassicaceae family. Brassicaceae microgreens are an excellent source of both macroelements (e.g., K and Ca), and microgreens are an excellent source of both microelements (e.g., Fe and Zn) in a balanced human diet, and the consumption of microgreens could be a healthy-promoting strategy to meet the requirement of element dietary reference intakes, particularly for children.

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