Пищевая биотехнология

Food biotechnology

Review article

DOI: http://doi.org/10.20914/2310-1202-2021-1-102-107

Microgreens: a newly merging product, aspects, prospectives, and disadvantages

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Summary. In this article we demonstrate the connotation of microgreens, the newly merging product in the Russian market. Microgreens are normal plants planted in highly density on a substrate medium and harvested shortly after the first true leaves appear. Microgreens of many aromatic plants possess intensive flavour similar to its mature product. We also expound the aspects related to this product, including growth, harvesting time, Seeds utilization, light requirements, available suitable substrate, as well as the disadvantages related to its production. There is still a lot of controversy about the health benefits of consuming microgreens. Some researchers believe that there is currently not enough scientific evidence to support a higher nutrient level in microgreens than in mature plants. In this review, we discuss whether microgreening is a great addition to gardening or not. Still, other prospects for the future of this product indicates that the demand of the market for the microgreens will be strong especially with the wide spread of home-growing facilities like phytotrons and simple growing chambers.

Keywords: microgreens, nutritional value, antioxidants, superfood, vitamins, production

Introduction

According to the UN, by 2050 the world's population will grow to almost 10 billion people, which will put enormous pressure on the possibilities of modern agriculture [1].

Despite the fact that the percentage of people with insufficient access to food has dropped significantly over the past 50 years, from 60 % in 1960 to about 15 % in 2010, there are currently about 1 billion people who are chronically malnourished and about 2 billion more. suffer from a deficiency of essential micronutrients [2, 3].

In this context, and with projections and scenarios for a population growth of more than 9 billion by 2050 [4], it becomes necessary to focus our attention and efforts on finding innovative tools that can help solve this problem and ensure food security for the population. To meet the need for fresh, nutrient-rich and high-phytochemicals in the diet for healthy body development, the vegetable industry has introduced a new product: microgreens. Microgreens can be seen as a concept innovation in vegetable growing in general, with the potential to change the whole idea of vegetables [5].

Microgreens, also known as “vegetable confetti” [6] or “micrograsses” for aromatic herbs [7], are plant foods. Although they are often referred to as culinary delicacies used as an ingredient in high-end restaurant kitchens, they are becoming increasingly popular and are increasingly used in the daily diet of people.

Microgreens are emerging sector in vegetable products which are gaining popularity and increased attention. They are young and tender cotyledonary leafy greens that are found in a pleasing palette of colors, textures and flavors. Microgreens are a new class of edible vegetables harvested when either when first leaves have fully expanded and before true leaves have emerged or upon the appearance of first true leaves. Microgreens are normal plants planted at medium to high density and harvested shortly after the first true leaves appear. Harvesting is done by cutting the stem directly above the soil in which they grow, or above the roots if growing without soil. The time period from sowing to harvest is usually 7 to 14 days, in exceptional cases up to 21 days for some slower growing species such as celery. The collected product is a microstructure with stems, cotyledon leaves and the first (1–2) true leaves. Sometimes, depending on the species, the seed coat remains attached to the cotyledonous leaves and may also be considered edible [7]. Microgreens are classified as a new category of vegetables, distinguishing themselves from the more widely known sprouts and early cut leafy vegetables, also known as baby leaves.

Для цитирования
Othman A.J., Eliseeva L.G., Simina D.V. Microgreens: a newly merging product, aspects, prospectives, and disadvantages // Вестник ВГУИТ. 2021. Т 83. № 1. С. 102–107. doi:10.20914/2310-1202-2021-1-102-107

For citation
Othman A.J., Eliseeva L.G., Simina D.V. Microgreens: a newly merging product, aspects, prospectives, and disadvantages. *Vestnik VGUIT* [Proceedings of VSUET]. 2021. vol. 83 no. 1. pp. 102–107. doi:10.20914/2310-1202-2021-1-102-107

The harvested product is these microstructures with stems, cotyledonous leaves and the first (1–2) true leaves. Sometimes, depending on the species, the seed coat remains attached to the cotyledonous leaves and may also be considered edible [7]. Microgreens are classified as a new category of vegetables, distinguishing themselves from the more widely known sprouts and early cut leafy vegetables.

Young, leafy vegetables that are harvested by cutting and then sold lose nutrients before they reach the final consumer. Microgreens can be sold by keeping the sprouts alive in the soil or growth medium, and the end consumer can cut the product a few minutes before being used or consumed. This innovation of selling the product while it is growing guarantees a longer shelf life and guarantees high quality in terms of freshness and nutritional value [7].

Of the three product categories (seedlings, microgreens, young leaves), only "seedlings" have a legal definition and their production and commercialization must comply with strict regulations due to their relatively higher risk of microbial contamination [6]. Easy sprouting and fast growing crops are suitable for growing as microgreens. Microgreens include many common types of vegetables and greens. The various types of microgreens include: cabbage, radish, turnip, carrot, beet, chard, peas, broccoli, cabbage, bok choy, celery, sesame, amaranth, watercress, lettuce, endive, arugula, mustard, sunflower, alfalfa, clover, sorrel, canola, chia, flax, fennel, dill, basil, cilantro and chervil. Microgreens are planted with the same seeds used to grow their full-sized counterparts. The basic concept of growing microgreens is collecting plants while they are still young. Microgreens provide a wide variety of flavors, colors and textures.

The scientists hypothesized that producing microgreens from local varieties of traditional vegetables and wild types of vegetables would be more profitable due to their higher nutrient content compared to commercial improved varieties.

Production Methods, Pest Management, and Harvesting

Microgreens can be grown on a small scale by individuals for home use or on a large scale in industrial production systems for commercial marketing. Growing, harvesting, and post-harvest handling can have a significant effect on the accumulation and degradation of phytonutrients in microgreens.

When it comes to growing conditions, microgreens are a versatile product. They can be grown in a greenhouse or indoors, with natural or artificial light sources, in soil or in soilless systems.

Recently, we started to see some microgreens products sold in Russian markets. In case if microgrees were grown outdoor, the production time could vary upon the season and crop variety. During spring to summer seasons when days are long and warm, seeds of radished from (Raphanus raphanistrum subsp. Sativus) family can be harvested in 5–7 days from germination. But, because frosts and cold in most of Russian areas, the growing area has to be in closed controlled rooms or growing chambers like phytotron of synergetrons, where all factors affecting growth can be controlled in isolation from the surrounding environment.

The microgreens are grown in 25 × 50 cm flats or blocks of nearly inert materials like growing on flat jute, cannabis fibers, coco hair, and polystyrene sheets or it can be grown on blocks that are filled with peat and vermiculite or perlite alone, together or mixed with other fine commercial ready substrates mixtures.

It is recommended in order to avoid washing out the drainage holes when it is watered to place a polyethylene sheet or paper towel over the bottom of the block to prevent the fine potting mix before filling the block with the substrate materials. The growing blocks is filled only to a depth of about 2–3 cm.

Currently, the sowing process is still done manually, hand seeding may be the most efficient method for small operations. There are several brands of hand seeders available, but, for small amounts of seeds, it takes more time to fill and empty the seeders than it does to seed manually. Since seed size varies, the volume of seed used varies. Approximately, 50 seeds of any variety is enough to spread them on a substrate area of 15 × 20 cm. If seeds were sown closely to each other's, some of them could not have the chance to grow in a correct manner. Results can be clearer upon harvesting. However, if only little number of seeds were sown, then the efficiency of the production per unit area will be proportionally inefficient. For small scale production, it is probably better to cut the greens upon order, so they are always cut no more than 24 hours before delivery. Colors and flavors are usually mixed in the boxes for a “rainbow” mix. But some chefs wish to buy a single variety or a specific mix (for instance, a spicy one made with radishes, arugula, and mustards).

Introducing microgreens into the market could be as mixes of different varieties (ready to eat salads) or as single variety. Most restaurants are willing or demanding to buy a single variety of microgreens or a specific mix of them, consequently, rising another challenge for growers for anticipating the demands of chefs. Some chefs prefer to buy the greens uncut in the flat and cut their own as needed. They should be advised that, to keep them longer than 1–2 days, they need to be able to put them in full light. Often they do not have that option in a restaurant kitchen.

The substrate aspect

Traditional microgreening is recommended for individual growers, but hydroponic growing systems perform better on larger scale. These systems use a variety of soilless media. The main substrates used for the production of microgreens are peat-based mixtures and synthetic mats. Since these types of substrates are expensive and not renewable, scientists have tried to find alternative solutions. The study was carried out on microgreens "rapini" (Brassica rapa L., Broccoleto group).

The results of this study showed that, in addition to polyethylene terephthalate and peat, other alternative low-cost substrates (textile fibers and jute-kenaf fiber) can be used. Another conclusion of the study is that the choice of growing medium is one of the most important aspects that have a significant impact on the productivity, quality and safety of microgreens, and the Kenaf jute fiber substrate performs better than the other substrate, which in turn, contributed to our choice of producing a safer and more optimized microgreen product.

Seeds utilization aspect

The production of microgreens requires a large amount of seeds, which entails high costs. The seeds used for microgreening must be of high quality and have a germination rate of more than 95 %. Also, the seeds must be of a good percentage of purity and free of pathogenic bacteria or mold.

As foodborne disease outbreaks have been reported over time due to infection of Escherichia coli O157: H7 germs, their production is now subject to a number of international regulatory standards. In this regard, in the Russian Federation there are no standards for the microbiological safety of microgreens.

Scientists have studied the possibility of these bacteria growing in various microgreen growing systems using seeds inoculated with Escherichia coli O157: H7. The results showed that bacteria grew on both microgreeny plants and growth substrates. The survival and proliferation of bacterial cells was higher in the hydroponic production system than in the soil substitute system [8] (Xiao et al., 2015). Another comparative study conducted earlier comparing the growth of this pathogen during germination and microgreen growth concluded that significant proliferation of E. coli O157: H7 and O104: H4 occurred both during germination and during microgreen growth. This means that the production of microgreens must comply with the food safety standards applicable to seedlings [9].

Light aspects

The light environment plays an important role in the development and accumulation of phytochemicals in microgreens. Some microgreens (dill, cilandro, chervil, argala, amaranth) grow best in indirect sunlight, but artificial light also promotes plant growth and can be optimized for the best results. There are many types of artificial light sources used in the production of microgreens, among them a light emitting diode (LED) is the best choice. LEDs are designed to emit visible light and have been proven to be an effective radiation source for plant growth [10, 21]. LEDs require the least amount of energy to produce light and very little heat, making them the most efficient and economical compared to other artificial sources.

Some research has focused on increasing the accumulation of shoot tissue nutrient pigments in leafy vegetables that control light source. Speaking of artificial light sources, the important parameters are the light spectra and the light level.

A group of scientists [11] published a study on the influence of LED illumination on growth, nutritional quality and antioxidant properties of Brassica microgreens. They used a high light load to activate the photoprotection mechanism in microgreens. As a result, the production of antioxidants (anthocyanins, alpha-tocopherol and ascorbate) is increased.

The study concluded that moderate levels of light are more effective in enhancing the nutritional value of microgreens, while strong lighting can have a detrimental effect on product quality. Depending on the species, the most suitable conditions for the growth and nutritional value of microgreens were 320–440 $\mu mol\ m^{-2}s^{-1}$ [22]. To establish the optimal level of illumination, the scientists took into account both agronomic and economic aspects.

The influence of the light source on microgreens was also studied. Researchers compared the effects of fluorescent light/incandescent light and blue/red LED light on the pigment content of 30-day-old Chinese cabbage (Brassica oleracea var. Alboglabra). They found that LED lighting from a single source promoted higher concentrations of carotenoid and chlorophyll pigments in cabbage microgreens.

Nutritional benefits of microgreens

Several studies over the past two decades have shown that the old adage "We are what we eat" is true. Sometimes our diets do not provide all the nutrients, minerals, vitamins and antioxidants we need for health. We often use pills to solve the problem quickly and easily. But are these supplements effective? Functional foods with a moderate concentration of bioactive compounds seem to be much better absorbed by our bodies than concentrated supplements.

Clinical trials as well as epidemiological studies have shown that a plant-based diet high in fruits and vegetables is associated with a reduced risk of cancer, cardiovascular disease and other chronic diseases.

Several bioactive plant compounds, commonly referred to as antioxidants, appear to be responsible for this beneficial effect. The evidence that bioactive compounds in vegetables have important health effects is a strong motivation for people to increase their intake of fruits and vegetables. An important strategy for increasing the intake of biologically active substances related to health is to increase their concentration in food plants. In this respect, microgreens are a desirable product in the market. Thus, microgreens belong to a group known as "functional food".

Different types of microgreens contain different amounts of functional compounds such as antioxidants, minerals, vitamins, and phenols. Growing, harvesting and storage conditions can have a significant impact on nutrient content.

Researchers estimated the concentration of vitamins and carotenoids in 25 microgreens. The highest concentrations of vitamin C, carotenoids, phylloquinone and tocopherols were found in red cabbage, cilantro, pomegranate amaranth and daikon green radish. The study concluded that microgreen cotyledon leaves have higher nutritional value than mature leaves. The researchers also found that the vitamin levels in microgreens are about five times higher than in their mature plants [12].

Researchers at the Laboratory for Food Quality and the Laboratory for Crop Production Systems and Global Change, USDA-ARS, conducted a study that analyzed the concentrations of macronutrients (calcium, magnesium, phosphorus, sodium, potassium) and micronutrients (copper, iron, manganese and zinc) in 30 microgreen species from 10 genera of the Brassicaceae family.

The results showed that Brassicaceae microgreens are a good source of macronutrients (such as potassium and calcium) and micronutrients (such as iron and zinc). This study appears to be the first document on the mineral content of commercially available Brassicaceae microgreens [13].

The protective effect against oxidative stress exhibited by Brassicaceae (broccoli, Brussels sprouts, cabbage, cabbage, cauliflower) is provided by glucosinolates, which are sulfur-containing glucosides.

For example, broccoli contains: sinigrin, glucoraphanin, and progoitrin; Chinese cabbage has indolyl glucosinolate glucobrassicin, and glucoraphanin is one of the most common glucosinolates found in broccoli.

Vegetables of the Brassicaceae family are also known to contain high concentrations of polyphenols associated with human health: anthocyanins, flavonol glycosides, hydroxycinnamic acids, etc. Assuming microgreens are more nutritious than mature plants, other researchers have compared five Brassica species. The results showed that microgreens contain more diverse complex polyphenols than mature plants. 164 polyphenols were identified, of which 30 were anthocyanins, 105 were flavonol glycosides, and 29 were derivatives of hydroxycinnamic and hydroxybenzoic acids, which proves that microgreens are an important source of biologically active substances [14].

The salad contains a variety of health-promoting phytochemicals, including vitamins and phenolic compounds with antioxidant properties. The researchers found that young lettuce (Lactuca sativa) seedlings after 7 days of germination had the highest total phenolic concentration and antioxidant capacity compared to mature leaves [15, 16].

For most people, when talking about food, sensory attributes are no less, and perhaps more important than nutritional value. Appearance, texture and taste are the main sensory attributes for judging the quality of fresh produce.

The chemical composition and sensory qualities (sweetness, bitterness, astringency, sourness, heat) of some microgreens were assessed in a study conducted [8]. Six types of microgreens were evaluated: Dijon mustard (*Brassica juncea L. Czern.*), Opal basil (*Ocimum basilicum L.),* bovine beet (*Beta vulgaris L.*), red amaranth (*Amaranthus tricolor L.*), watercress (*Lepidium bonariense L.*) and Chinese radish (*Raphanus sativus L.*). Researchers have found a strong correlation between the chemical composition (total phenols) of microgreens and their taste. Chemical analysis showed that Chinese radish, opal basil, and red amaranth have the highest concentrations of total ascorbic acid, phylloquinone, carotenoids, and tocopherols, while the highest concentrations of total phenolic compounds were found in Chinese pink radish and opal basil [23, 24].

The study also concluded that pH values and total phenolic compounds can be used by microgreen growers as indicators and predictors of consumer acceptance. Unfortunately, the results of the study reflected the fact that people refuse certain vegetables because of their unpleasant taste (bitterness, astringency), even if they have a beneficial effect on human health.

Disadvantages associated with microgreens production

The main two disadvantages associated with the production of microgreens are: short shelf life with reduced nutritional value during storage and the risk of contamination by pathogens and public health. The industrial production and marketing of microgreens is limited by their short shelf life associated with a rapid deterioration in product quality. Various methods are currently used before and after harvest to prolong the shelf life of microgreens.

Post-harvest methods are related to storage conditions and require tight control of temperature and atmospheric composition. Thus, the shelf life of microgreens depends on many factors, such as temperature, relative humidity, type of packaging film and microbial load. Researchers have tried to find solutions to avoid product degradation during post-harvest storage.

Related studies have been carried out on extending the shelf life of buckwheat microgreens [20]. Although microgreens from buckwheat are rich in antioxidants and vitamins, their short shelf life limits their commercial use. In this study, an attempt was made to optimize storage conditions in order to preserve the nutritional quality of the product.

Temperatures between 5° C and 10° C and an atmosphere with moderately high O2 (14.0–16.5 kPa) and moderately low CO2 (1.0–1.5 kPa) have been found to be optimal for maximum shelf life [17, 18]. The researchers also optimized the packaging to provide the optimal atmosphere composition needed to extend the shelf life of buckwheat microgreens.

But the shelf life of microgreens can also be extended by using some preparation methods for harvesting. Scientists investigated the effect of preharvest calcium application on the quality of broccoli microgreens. The post-harvest quality and shelf life of the treated microgreens increased to 21 days [17].

Untreated microgreens were edible for only 14 days. A dose of 10 mM calcium chloride increased biomass production (by more than 50 %), enhanced superoxide dismutase and peroxidase activity in microgreens, and significantly reduced microbial growth during storage. The treatment also tripled the calcium concentration in the microgreens.

In practice, in order to prevent the growth of microbes in the post-harvest stage, microgreens are washed with chlorinated water in doses that do not affect the taste and aroma of the product. Others have studied the effect of various disinfectants on the quality and microbial population of Brassica campestris var. microgreen farinosa. The scientists used the following disinfectants in various combinations: chlorine, citric acid, ascorbic acid, and ethanol spray. The results show that the combination of citric acid with an ethanol spray can successfully replace chlorine commonly used for washing microgreens [19].

Another disadvantage for growing microgreens could be their high prices, due to the production costs such as substrate media, the cost of seeds, and labor hood. Also, prices in some areas have dropped recently as larger growers have entered the market and developed more efficient production and harvesting methods.

Customers may try to save money by purchasing microgreens from large farms in other parts of the country, but then discover that the savings is not worth the difference in quality and shelf life of the product [25]. It is also more convenient for restaurants or brokers to be able to call up and order fresh microgreens for that day, instead of having to anticipate needs and place orders a day or two before, carrying a larger inventory. With rising fuel costs, the advantage for growers who are very close to their markets may even increase.

Conclusion

A healthy and well-balanced diet is the main strategy for achieving good health. Without a balanced diet based on functional foods such as microgreens, diets are likely to have less impact on public health. There is still a lot of controversy about the health benefits of consuming microgreens. Some believe that there is currently not enough scientific evidence to support a higher nutrient level in microgreens than in mature plants. But as this review has shown, microgreening is certainly a great addition to gardening. Microgreens can be a good crop for beginning growers. They are easy to grow and do not require a large infrastructure or initial investment in land or equipment. They are still newly merging into the Russian market, expectations prognosing that the demand of the market for the microgreens will be strong.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

RECEIVED 1.15.2021
ACCEPTED 3.3.2021