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Dear Sir,

Title: -MICROGREENS: A NOBEL FUNCTIONAL FOOD AND ITS IMPORTANCE

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Abstract

The rise in the living standards especially in urban dwellers rely heavily on lengthy food supply chains originated in rural areas, leading to limited access to perishable produce and logistical challenges in transportation. Consequently, numerous urban areas are categorised as 'food desserts', lacking adequate access to nutritious foods. Microgreens are young, miniature seedlings of vegetables and herbs, harvested when their cotyledons have fully expanded and their pair of true leaves are emerging or partially expanded. Typically measuring 1-3 inches in height, microgreens reached this stage within 7-14 days post-germination, though the timing can vary based on crop type, variety, and environmental factors. They consist of a central stem, two cotyledon leaves, and often the first pair of young true leaves. They are esteemed for their abundant micronutrients and phytochemicals. Microgreens are abundant in phytochemicals, minerals, and other bioactive substances. *The levels of vitamins A, C, E, K, enzymes, and carotenoids vary based on the type of microgreen.* This nutritional density has been associated with a lower risk of heart disease and cancer, among other diseases. Thus, including microgreens in one's diet can provide a proactive way to enhance general health and delay the onset of these *debilitating conditions. The spectrum of microgreens encompasses a vast array of plant species, ranging from mustard and radish to kale and basil, playing a crucial role in sustaining a healthy ecosystem. Due to essay accessibility, economic viability, and market demand positions microgreens as a promising avenue for sustainable livelihoods and business ventures. A surge in microgreens research has spurred interest in investigating their composition and future studies. The article provides an in-depth analysis of Microgreens nutritional significance, highlighting their potential benefits.*

***Keywords**: Bioactive compounds, Microgreens, Sprouts, Nutritional value, Antioxidants*

INTRODUCTION

The rise in the living standards encompassing social, economic, and cultural aspects has triggered prevalent lifestyles issues such as disease and nutritional gaps. A looming challenge is the scarcity of fresh, pesticides-free vegetables for consumption. Urban dwellers rely heavily on lengthy food supply chains originated in rural areas, leading to limited access to perishable produce and logistical challenges in transportation. Consequently, numerous urban areas are categorised as 'food desserts', lacking adequate access to nutritious foods [1], [2].

Microgreens, a term coined for emerging food products derived from various commercial crops like vegetables, grains, and herbs, are prized for their densely packed nutrients, intense flavours, delicate textures, and vibrant hues. These are young, miniature seedlings of vegetables and herbs, harvested when their cotyledons have fully expanded and their pair of true leaves are emerging or partially expanded. Typically measuring 1-3 inches in height (figure 1) , microgreens reached this stage within 7-14 days post-germination, though the timing can vary based on crop type, variety, and environmental factors. They consist of a central stem, two cotyledon leaves, and often the first pair of young true leaves. Distinct from both sprouts (germinated seeds consumed with their embryonic root and seed) and baby greens, microgreens occupy a middle ground, earning them the playful nickname **"vegetable confetti."** [2]**,** [3]**.**

A**s** far as the 1980s, microgreens started appearing on the menus of chefs in San Franciso. In the mid-1990s, Southern California began cultivating microgreens, initially offering a limited selection including arugula, basil, beets, kale, cilantro, and a vibrant mix dubbed the "Rainbow Mix." From California, the trend spread across the United States, with a growing number of varieties now being grown in most regions of the country. Presently, the U.S. microgreens industry encompasses various seed companies and growers [4].

Among the commonly cultivated microgreens are spinach, mustard, buckwheat, arugula, bulls blood beet, celery, cilantro, amaranth, basil, red cabbage, and more. Each variety offers a distinct flavour profile; for instance, methi (*Trigonella foenum-graecum*) presents a slightly bitter taste, mustard offers a bit spiciness, and radish microgreens carry the flavour reminiscent of mature radish [1], [2].

To cultivate microgreens successfully, its crucial to ensure a consistent supply of moderately acidic water. Typically, several types of seeds are soaked over night to enhance germination rates. During germination, it

is important to cover and shield the flats form light. After approximately three days, the plants should be gradually introduced to light exposure. Daily watering is necessary until the leaves begin to emerge [1], [3], [5].

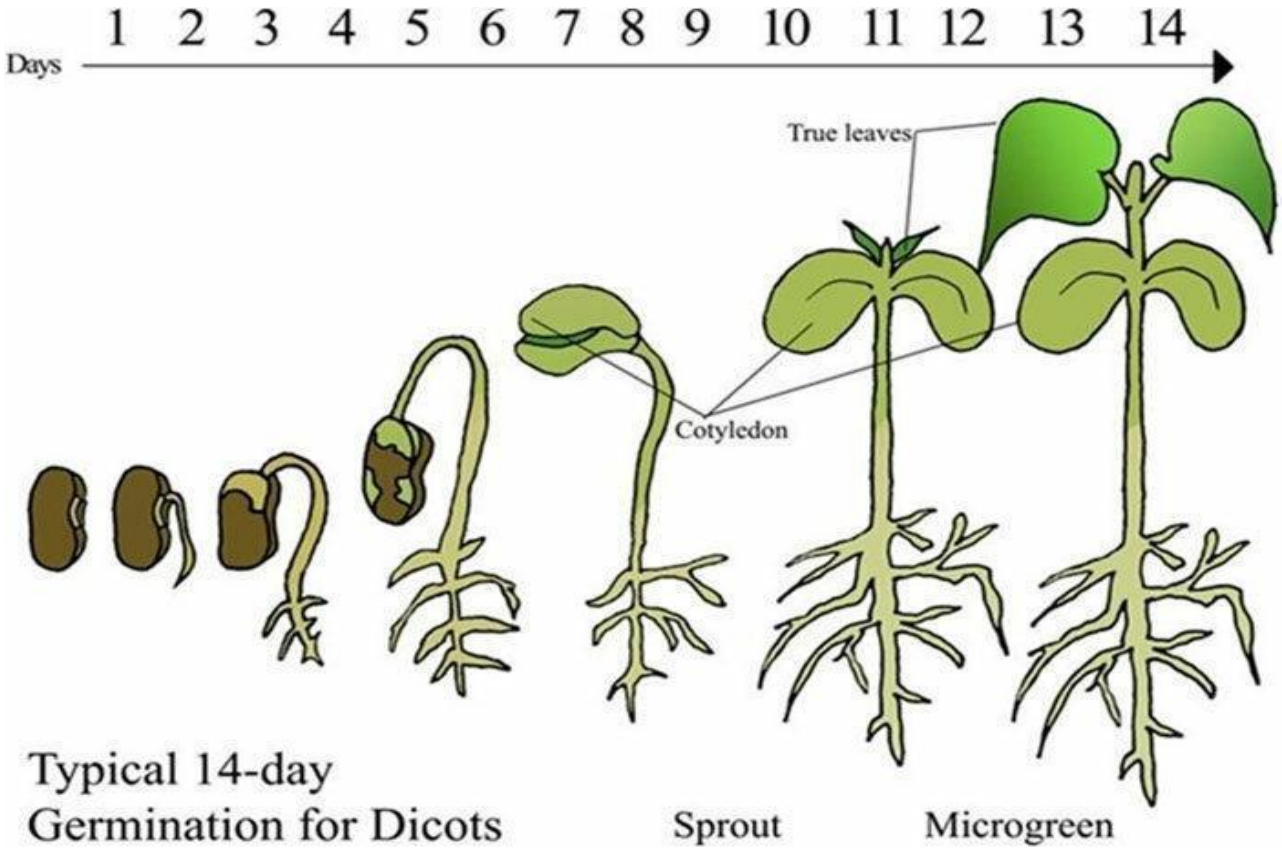

Figure 1: - Older Than Sprouts and Younger Than Baby Greens (Source-- Kalpana Yadav, 2021) [2]**.**

Different types of microgreens

Microgreens can originate from a wide range of seeds types, with the most popular ones belonging to various plant families: [1], [6], [7], [8].

Brassicaceae Family: Involves cauliflower, broccoli, cabbage, watercress, radish, and arugula.

Asteraceae Family: Consists of lettuce, endive, chicory.

Apiaceae Family: Having carrot, fennel, and celery.

Amaranthaceae Family: Contains amaranth, quinoa, Swiss chard, beet and spinach.

Amaryllidaceae Family: Comprises garlic, onion, and leek.

Cucurbitaceae Family: Involves melon, cucumber, and squash.

Lamiaceae Family: Includes mint, basils, rosemary, sage and oregano.

Poaceae Family: Includes grasses and cereals like barley, corn, oats, and wheatgrass. As well as legume including beans, chickpea, and lentils.

Nutritional composition

Microgreens are abundant in phytochemicals, minerals, and other bioactive substances.. The levels of vitamins A, C, E, K, enzymes, and carotenoids vary based on the type pf microgreen, growing conditions such as medium, sunlight exposure, temperature, and harvesting time. Brightly coloured microgreens tend to be more nutrient- dense than the lighter ones, boasting higher levels of alpha-carotene, beta-carotene, violaxanthin, lutein, and neoxanthin compared to sprouts. They also contain elevated amounts of protein, iron, and zinc. Additionally, microgreens have low levels of antinutritional factors like nitrate (NO3) and nitrite (NO2) [1], [4], [9].
A study was carried out to investigate the effects of red cabbage microgreens on the cholesterol and lipid levels of mice that were fed a high-fat diet. Their findings revealed that microgreens effectively curbed weight gain induced by the high-fat diet. Moreover, microgreen supplementation significantly decreased hepatic cholesterol ester and triacylglycerol levels, downregulated inflammatory cytokines in the liver, and decreased circulating LDL levels in animals fed a high-fat diet [3], [10]. These results suggest that microgreens have the potential to modulated weight gain and cholesterol levels, especially red microgreens which are rich in polyphenols and glucosinolates compared to mature red cabbage. Additionally, red cabbage serves as a plentiful source of vitamin C. (**Huang et al. 2016).** Investigated how Brassicaceae microgreens inhibit the growth of human colon cancer cell. Their research encompassed cell viability assays and investigations into the mechanism underpinning the anti-proliferative activity. The findings revealed that the antioxidant bioactive compounds present in these microgreens effectively inhibited tumor cell proliferation, owing to their high concentration of bioactive compounds [3], [11] , [12]. Consequently, the study suggested that integrating microgreens into a well- balanced diet on a daily basis could serve as a dietary strategy to mitigate chronic degenerative ailments such as colon cancer Caco -2 cell. (**Fuente et al. 2020).**

Microgreens, particularly those belonging to the *Brassica oleracea* L. species, boast a wealth of essential nutrients and a plethora of bioactive compounds, with glucosinolates (GLSs) being particularly prominent [4]. Research, such as the study conducted, highlights the anti-carcinogenic, anti-inflammatory, antimicrobial, and anti-obesity effects attributed to these compounds. **(Le et al. in 2020).**

Table 1. Nutritional profile of 10 culinary microgreens (Ghoora et al., 2020)

MICROGREEN	TOTAL PROTEIN g/100g	TOTAL DIETARY FIBRE g/100g	TOTAL ASH g/100g	POTASSIUM mg/100g	IRON mg/100	ASCORBIC ACID (mg/100g)	BETA CAROTENE (mg/100g)
Carrot	2.42±0.03	2.46±0.19	1.42±0.01	314.5±3.0	0.44±0.01	65.6 ± 4.4	5.8 ± 0.6

Fennel	4.44±0.51	4.28±0.16	1.67±0.01	480.5±6.0	1.79±0.03	52.5 ± 2.7	9.1 ± 0.2
Fenugreek	3.33±0.06	1.48±0.04	0.48± 0.02	118.5±1.0	1.00± 0.01	92.7 ± 0.5	3.1 ± 0.0
French Basil	2.22±0.32	1.41±0.07	1.30±0.00	328.6±4.8	2.17± 0.09	96.3 ± 2.7	6.8 ± 0.2
Mustard	2.78±0.00	2.08±0.18	1.03±0.03	322.8±3.0	2.46± 0.01	57.1 ± 1.8	7.4 ± 0.2
Onion	2.58±0.14	1.93±0.11	0.67±0.05	273.9±1.9	0.99± 0.02	29.9±2.5	3.8±0.1
Radish	1.81±0.03	1.78±0.01	0.77±0.01	251.4±1.8	0.95± 0.15	88.5±2.2	7.6±0.1
Roselle	2.55± 0.10	2.40±0.14	1.03±0.01	214.6±5.8	1.62± 0.02	123.2±4.0	6.4±0.2
Spinach	2.32± 0.30	2.36±0.05	1.44±0.01	69.7±1.5	1.88± 0.03	71.2±1.8	6.1±0.4
Sunflower	3.93± 0.05	3.63± 0.04	0.81±0.00	331.1± 1.5	1.44± 0.01	86.2±3.0	4.5±0.2

A study was conducted in India, which discussed the varieties in micronutrient, macronutrients, and oxalate contents among 10 different culinary microgreens. The nutritional composition of these microgreens is outlined above. he study also looked at the nutritional value of other microgreens' constituents, such as oxalic acid, magnesium, phosphorus, sodium, tocopherol, zinc, and selenium. It identifies potassium as the primary macro-element and iron as the key micro-element in the microgreens (**table 1**). The research concluded that radish, French basil, and roselle were the most nutrient-rich microgreens among the species studied [13]. This pioneering research provides a valuable nutritional ranking of microgreens, offering guidance for consumers in making dietary decisions. (**Ghoora et al., 2020**) [8].

HEALTH BENEFITS OF MICROGREENS:

Given the rich concentration of vitamins, minerals, and beneficial plant compounds found in microgreens, their consumption is linked to a reduced risk of various disease microgreens bestow upon us essential nutrients that serve as a shiels against illness (**Bazzano et al.,2002; Carter et al.,2010)** [8]**,** [14]**.**

1. HEART DISEASE: Microgreens boast abundant antioxidant such as polyphenols, known for their potential in reducing the risk of heart disease. Various animal studies have consistently indicated that microgreens have the ability to decrease triglycerides levels and harmful LDL cholesterol **(Huang et al.,2016; Tangney and Rasmussen,2010)** [7]**,** [8] , [15].

2. ALZHEIMER'S DISEASE: Food abundant in antioxidant, like polyphenols, can lower the risk of memory-related conditions such as Alzheimer's disease (**Guest and Grant, 2016**) [7], [8], [16].

3. DIABETES: Antioxidants presence can help reduce the risk of type 2 diabetes. Fenugreek microgreens, in laboratory experiments, are believed to enhanced cellular sugar uptake by 25-44% **(M.H.,1996; Wadhawan et al.,2018)** [7]**,** [8]**,** [17].

Achievements: -

1. In 2021, the United Arab Emirates embarked on the Emirates Mars Mission, marking a significant milestone in space exploration. A notable aspect of this mission is the groundbreaking experiment involving the cultivation of microgreens on Mars-like soil. Through meticulous research and experimentation, scientists achieved success in growing mustard seeds, arugula, and radish in a controlled environment, showcasing the viability of microgreens cultivation even in the harsh conditions of outer space. This pioneering project holds immense importance in unravelling the potential of microgreens to sustain future endeavours in space exploration and colonization.

2. **Microgreens for nutrition in Haiti:** Amidst the aftermath of natural disasters and persistent food security issues in Haiti, microgreens have emerged as a ray of hope. Organizations such as 'Project Haiti' have played a pivotal role in championing microgreens as a vital nutritional resource. Through collaborative efforts with local farmers and communities, they have facilitated the introduction of microgreens, empowering individuals to cultivate and incorporate these nutrient-rich greens into their diets. This initiative not only addresses malnutrition but also fosters self-sustainability within the community, offering a promising solution to the challenges faced in Haiti's food landscape.

3. Using microgreens to green the deserts: Programs like 'Desert Bloom Microgreens' in the United Arab Emirates are showcasing the potential benefits of microgreens in arid areas.

4. Through collaboration with local farmers and researchers, this project illustrates the feasibility of cultivating microgreens in desert conditions using hydroponic systems and controlled environments. The capacity to produce nutrient-dense crops in such harsh environments presents promising solutions to address global food security challenges, as highlighted in research.

5. **Aquaponics in Northern Ghana** (**WFP**): In Northern Ghana, the World Food Programme has launched a project blending aquaponics and microgreens farming to address malnutrition and enhances food security. This innovative initiative intertwines fish cultivation with microgreens growth, fostering a sustainable and nutrient-dense food ecosystem, with microgreens serving as a vital source if essential vitamins and minerals for the local populace. (**Vineeta Kumari et al. in 2023**) [18].

Importance and future prospects

1.Nutritional powerhouse -Microgreens are renowned for their concentrated nutritional content, boasting elevated levels of vitamins, minerals, bioactive compounds, phytochemicals, and antioxidants. This nutritional density has been associated with a lower risk of heart disease and cancer, among other diseases. So, adding microgreens to one's diet can be a proactive way to support general health and delay the onset of these crippling illnesses.
2. Crop diversification and biodiversity Microgreens are a diverse range of plant species that are essential to maintaining a healthy ecosystem. They include things like radish, mustard, and basil. Global microgreens initiatives have aggressively encouraged the production of a wide range of cultivars, promoting biodiversity and protecting traditional and heirloom crops.

1. This diversification not only enhances resilience against pests, diseases, and environmental fluctuations but also serves as a strategic approach to crop selection. Factors such as seedling colour, texture, flavour, and market demand influence the choice of crops, ensuring a harmonious balance between ecological sustainability and market viability.

2. **Economic opportunities:** Microgreens cultivation presents an accessible option for small-scale farmers and entrepreneurs, requiring minimal space and investment. These projects not only offer economic opportunities but also serve as catalysts for entrepreneurship and poverty reduction within communitiesv. This combination of accessibility, economic viability, and market demand positions microgreens as a promising avenue for sustainable livelihoods and business ventures.

Environmental sustainability – Microgreens stand out for their resource efficiency, demanding less water, space, and fertilizers compared to mature crops. International microgreens initiatives usually use sustainable farming practices, such as organic gardening and water-saving measures.

3. . By championing such practices, these initiatives play a vital role in the global endeavour to combat climate change and mitigate agriculture's environmental footprint. This emphasis on sustainability not only promotes environmental stewardship but also underscores the potential of microgreens to lead the way towards more eco-friendly agricultural practices on a larger scale**.**

CONCLUSIONS

Microgreens, emerging as a novel category of plant-based functional foods, consist of young edible plant seedlings harvested within 7–14 days of germination. They are rich in phytochemicals such as essential minerals, polyphenols, carotenoids, chlorophyll, anthocyanins, and glucosinolates, contributing to potent antioxidant, anti-inflammatory, and anti-diabetic effects. This positions them as promising dietary components capable of potentially ameliorating chronic diseases. The diversity among microgreen species further enhances their health benefits. Nonetheless, challenges persist in optimizing production, storage, and consumption methods to maximize growth rates and yields. Addressing microbial colonization and disease prevention is crucial to mitigate food safety risks. Exploring the metabolic profiles of different microgreen varieties promises insights into their biological activities. Advancements in production technology,

packaging, and shelf-life maintenance are imperative for wider adoption. Despite promising indications for managing metabolic disorders, comprehensive evidence and mechanistic understanding are still evolvingTo validate claims and investigate their potential as personalized medicine, more research is required.. Educating consumers on nutritional benefits, preparation methods, sensory attributes, and palatability will promote their adoption for improved health outcomes.

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