Microgreens for Nutritional Security

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In this book, the readers will be introduced to key dimensions of microgreens as a nutritional resource. The scientific analysis of microgreens cultivated in various growth media. By understanding how different environments affect the nutritional content of these tiny greens, to shed light on the best practices for their cultivation. Microgreens are not just a source of nutrition but also an exciting culinary element.

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PREFACE

In a rapidly urbanizing world, the quest for ensuring nutritional security for urban populations has become an imperative. The challenges of urban living often lead to dietary choices that may not necessarily promote health and well-being. In this context, microgreens, a relatively recent culinary and nutritional phenomenon, have emerged as a promising solution to address the nutritional needs of urban dwellers. "The Promotion of Microgreens for Nutritional Security in Urban Areas" is a comprehensive study aimed at exploring the potential of microgreens to contribute to the nutritional well-being of urban populations. This book delves into various aspects of microgreens, from their growth and nutritional composition to their incorporation into everyday urban diets.

The research presented in this book unfolds through a multi-faceted approach, addressing key dimensions of microgreens as a nutritional resource. We have endeavored to provide a holistic view of this emerging field through four distinct yet interconnected components. The scientific analysis of microgreens cultivated in various growth media. By understanding how different environments affect the nutritional content of these tiny greens, we aim to shed light on the best practices for their cultivation. Microgreens are not just a source of nutrition; they are also an exciting culinary element. This chapter explores the creative possibilities of incorporating microgreens into recipes that are not only nutritious but also delicious. The standardization of these recipes ensures that microgreens can be seamlessly integrated into urban diets. Microgreens have garnered attention for their exceptional nutritional density. In this section, we compare the nutrient profiles of microgreens with their mature counterparts, offering insights into the potential advantages of including microgreens in our diets. Beyond just nutritional content, taste and sensory appeal play a crucial role in dietary choices. We explore the sensory aspects of microgreens and the palatability of recipes incorporating these greens, ensuring that they are not only nutritious but also enjoyable to consume.

This book is the result of rigorous research, dedicated exploration, and a genuine commitment to improving the nutritional security of urban populations. It is our hope that the insights and findings presented herein will not only contribute to the scientific understanding of microgreens but also inspire individuals, communities, and policymakers to embrace microgreens as a valuable resource for promoting health and well-being in urban areas.

As we embark on this journey into the world of microgreens, we extend our gratitude to the countless individuals, researchers, and organizations that have contributed to this field. It is our belief that microgreens have the potential to play a pivotal role in shaping the future of urban nutrition, and we invite readers to join us in this exciting exploration.

(P Chandra Shekara)
Director General, MANAGE

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Veenita

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Dr. Veenita Kumari

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Chapter-I
Introduction

Microgreens are vegetable greens harvested after sprouting as shoots that are used both as a visual and flavor component or ingredient primarily in fine dining restaurants. Fine dining chefs use micro greens to enhance the attractiveness and taste of their dishes with their delicate textures and distinctive flavors. Smaller than 'baby greens' and harvested later than sprouts, micro greens can provide a variety of leaf flavors, such as sweet and spicy. They are also known for their various colors and textures. Among upscale markets, they are now considered a specialty genre of greens that are good for garnishing salads, soups, plates and sandwiches.

In short, microgreens are leafy vegetables characterized by a central stem and cotyledonary leaves. Edible young greens and grains are produced from various kinds of vegetables, herbs or other plants. They range in size from 1 to 3 inches (2.5 to 7.6cm), including the stem and leaves. A micro green has a single central stem which has been cut just above the soil line during harvesting. It has fully developed cotyledon leaves and usually has one pair of very small, partially developed true leaves. The average crop-time for the micro greens is 10-14 days from seeding to harvest.

In the modern-day world of scientific advancements, micro greens are emerging fast as a functional food with abundant nutritional and therapeutic benefits. Usually, these are ideal for production in indoor environments. Microgreens are considered as part of international movement towards "controlled environmental agriculture" (CEA) towards achieving global food security.

Microgreens have gained increasing popularity as food ingredients in recent years because of their high nutritional value and diverse sensorial characteristics. Microgreens are edible seedlings including vegetables and herbs, which have been used, primarily in the restaurant industry, to embellish cuisine since 1996. The rapidly growing microgreen industry faces many challenges. Microgreens share many characteristics with sprouts, and while they have not been associated with any foodborne illness outbreaks, they have recently been the subject of seven recalls. Thus, the potential to carry foodborne pathogens is there, and steps can and should be taken during production to reduce the likelihood of such incidents.

One major limitation to the growth of the microgreen industry is the rapid quality deterioration that occurs soon after harvest, which keeps prices high and restricts commerce to local sales. Once harvested, microgreens easily dehydrate, wilt, decay and rapidly lose certain nutrients. Research has explored preharvest and postharvest interventions, such as calcium treatments, modified atmosphere packaging, temperature control, and light, to maintain quality, augment nutritional value, and extend shelf life. However, more work is needed to optimize both production and storage conditions to improve the safety, quality, and shelf life of microgreens, thereby expanding potential markets Microgreens have been predominantly used in the restaurant industry in improving the characteristics of cuisines like salads, soups and sandwiches. However, despite their rapid growth, microgreens face certain setbacks and roadblocks. Microgreens are known for leading to damage after the postharvest process. Due to high rate of respiration, early senescence and high surface area to volume ratio etc., micro greens are very difficult to preserve.

Even though microgreens are small in size, they have good concentrations of antioxidants, vitamins, bioactive compounds and nearly 40% of vital nutrients than their mature greens. Henceforth, the production of these nutrient-rich rapidly growing microgreens is considered an amiable solution for the consumption of pesticide free vegetables. This, many believe is expected to reduce chronic illnesses and malnutrition.

Most research on microgreens has taken place in the last 7 years by a limited but growing number of international research groups ((Brazaitytė et al., 2018; Craver, Gerovac, Lopez, & Kopsell, 2017; Kyriacou et al., 2016; Riggio, Wang, Kniel, & Gibson, 2019b; Xiao et al., 2012). Each group has focused on a narrow subset of microgreens and their issues. The intention of this review is to fit together these pieces and bring attention to the areas that are potential impediments to commercialization.

Functionality studies carried out in rodent models for exploring the various health benefits of microgreens proved that microgreens in red cabbage decreased fat-induced increase of weight and incidentally decreased the polyphenols, thus proving a high antioxidant and anti-inflammatory properties in microgreens. Phenolic compounds, also seem to have an influence on sensory qualities of microgreens. Studies reported that the total phenolic concentration was strongly correlated with the overall eating quality and several aspects of sensory qualities, including intensity of astringency, sourness, bitterness, and sweetness of microgreens spite of the increase of research on microgreens, no study has evaluated the nutritional and sensory qualities of these specialty vegetables grown differently or from different sources. Such information is important for consumers in purchasing or for health professionals in conducting research or giving dietary advice. Therefore, the main objective of this study was to investigate the nutritional qualities and sensory properties of microgreens grown and harvested in a commercial setting versus a local farm setting. The nutritional analysis will focus on chlorophyll content, phenolic compounds content, vitamin-C content, and antioxidant capacity, which are known to contribute to the health benefits or sensory attributes of microgreens. Since broccoli microgreen is the only species available to researchers in both local grocery stores and local farms, it was selected for the comparison in nutritional and sensory qualities. In addition, six other microgreens that available in local farms were also analyzed for nutritional quality. We hypothesized that microgreens grown in soil in a farm setting would possess higher nutritional qualities and produce better sensory properties as compared to those grown hydroponically and those from a commercial source.

Microgreens cultivation needs a good supply of moderate acidic water. Usually, a few varieties of seeds are soaked overnight to improve the rate of germination. The flats are covered and protected well from light during germination. After nearly 3 days, the plants will be exposed to light. They will be watered daily till the leaves start coming up.

Advantages of Microgreens in Urban Areas:

The word "Microgreens" is a marketable and marketed term often used to talk about tender and young siblings. They have the following advantages.

Superfoods:

Microgreens are superfoods, loaded with vitamins, minerals, and antioxidants. These little green plants possess more nutrients than regular leafy vegetables. When microgreens are part of your daily diet, the health benefits will be evident. After heavy calorie intake in holidays or festivals, the fastest way to detox yourself is by growing and consuming microgreen vegetables.

Fastest Harvest:

Microgreens produce the quickest edible plant harvest ever. Micro-methi can be harvested 8-10 days after seed sowing. Other microgreen leaves like spinach, Amaranth, Mustard are also collected within 10-12 days of planting. Therefore microgreens are best suited for a fast-paced urban lifestyle.

Require Less Sunlight:

Unlike conventional kitchen garden plants like fruiting vegetables, microgreens require less sunlight. Only 2-3 hours of direct sunlight is enough to start microgreen farming. Therefore, these can be effortlessly grown in the urban home gardens.

Window Farming:

With less sunlight requirement, microgreens are perfect for window farming in city apartments. Microgreens can be grown in compact places, and your regular supply of greens can be obtained from window-sills of the average sized house. You don't need a terrace or spacious balcony to grow microgreens.

The Subtle Joys of Gardening:

Since microgreens are so rewarding in a quick time, they become favourites of hard-core gardeners and amateurs alike. The fun gardening activities like sowing, watering, harvesting are very satisfying when it comes to growing microgreens. Microgreen gardening is also a therapeutic activity due to its engaging nature.

Soilless Gardening:

To grow microgreens, the soil is not compulsory, hence you don't have to worry about the muddy situation. Microgreens show best results when grown in cocopeat based growing medium along with compost/ vermicompost/ peat moss/ leaf mould etc. In aquaponics systems, microgreens can be produced directly in water.

Best Salad:

Microgreens are not supposed to be cooked and should be consumed raw and fresh to obtain all the health benefits from it. This makes it the best salad material, with a little bit of stir-frying, or just eating it with salt, pepper, and lemon juice.

Decorative Garnishing:

Microgreens are commercially used for garnishing the dishes of various cuisines in restaurants. The dark green of kale, pale green mustard, dark red of Amaranth etc. provide multiple colour combinations for food decorations and pretty looking salads.

Appealing to Children and Youth:

Children refusing to eat leafy vegetables is an age old problem that all parents face. This is where microgreens come to the rescue. Microgreens can be used to raise children's curiosity and can be cleverly included in their favourite snacks like burger, sandwiches, pizza and pasta. Children can also be encouraged to grow their food through microgreen farming projects.

Micro-Roots:

It's not just leafy greens; one can also grow micro-roots. The rooting vegetables like carrot, beetroot, radish, turnip etc. can also be produced in microforms. Point to be noted here is that all leaves of micro-roots are also edible, therefore entire plant should be harvested at the right time. Micro-roots look cute and are tasty too.

Why Are Micro-Greens In Demand?

Microgreens are high in demand basically because of their rich nutritional content. A research by University Of Maryland College Of Agriculture and Natural Resources (AGNR) and the United States Department of Agriculture (USDA), approves that micro-greens have more nutritional value than what their mature counterparts have. It was found that the micro-greens hold 4 to 40 times more nutrients than their mature counterparts.

Benefits of Micro-greens Farming:

- Micro-greens are quick to grow because they hardly take two or three weeks' time to grow and being harvested.

- Many plant types can be grown together in a small area. Therefore Micro-greens farming is considered to have high yield to space ratio.
- Healthy, organic, green food can be grown in minimum time with less effort.
- People living in an urban area where farming or gardening is difficult due to space constraints, Micro-greens farming is a perfect solution.
- The basic requirements for Micro-greens farming are simple: water, good light, tray and tables for setting up plants and growing medium.
- Green leaves for salads, soups, garnishing and sandwiches are all season crops and can be grown as Micro-greens in any climatic condition.
- Micro-greens can be grown as a kitchen garden in an extremely small balcony of shade house without the need for any extra space or equipments.
- Micro-greens are nutrient rich food with a variety of digestible vitamins, minerals and phytonutrients. They contain living enzymes and nutrients along with good flavor, color and texture.
- Micro-greens are generally not cooked before serving. Using Micro-greens in this way maximizes the nutrient intake content because there is no loss of nutrients.
- The texture of Micro-greens is delicate and crunchy which is why they are used as garnishing agents.
- Once the seeds are sown, many types of Micro-greens grow again and can be harvested several times**.**

Different Types of Microgreens

Microgreens can be grown from many different types of seeds. The most popular varieties are produced using seeds from the following plant families:

Brassicaceae Family: Cauliflower, broccoli, cabbage, watercress, radish and arugula

Asteraceae Family: Lettuce, endive, chicory and radicchio

Apiaceae Family: Dill, carrot, fennel and celery

Amaryllidaceae Family: Garlic, onion, leek

Amaranthaceae Family: Amaranth, quinoa swiss chard, beet and spinach

Cucurbitaceae Family: Melon, cucumber and squash

Storage and Shelf Life of Microgreens:

When microgreens are harvested, they a have high respiration rate (Chandra et al., 2012; Mir, Shah, and Mir 2017) stated that shelf life of micro greens is three to five days at ambient temperature. However, it would be unwise to store any harvested leafy green at ambient temperature. The greatest "shelf life" of microgreens is achieved by selling them still rooted in the growth medium. Harvested microgreens must be kept cold to maintain quality. Depending on cultivar and storage conditions, quality may be maintained for over 14 days. There are no food code requirements for microgreens, but preliminary studies suggest that microgreens should be stored at temperatures of ≤5 °C (Kou et al., 2013; Xiao et al., 2014b). Microgreens resistant to chilling injury can be held as low as 1 °C (Berba & Uchanski, 2012). Microgreens freeze rapidly if held below 0 °C, causing substantial physical damage.

Although high humidity is necessary to prevent dehydration, it also promotes microbial growth and decay (Zagory & Kader, 1988). Thus, a combination of adequate cold chain and suitable modified atmosphere packaging (MAP) are essential to reduce respiration rates, prevent moisture loss, reduce environmental contamination, and inhibit growth of spoilage and pathogenic microorganisms (Berba & Uchanski, 2012; Zagory & Kader, 1988).

Packaging:

Microgreens may be washed after harvest to remove soil particles and provide a clean product for packaging. Washing greens prior to packaging reduces initial bacterial load, but creates a humid environment which promotes microbial growth and necessitates removal of excess water to discourage such growth. Many growers choose not to wash them, as the additional handling that washing and dewatering entail can damage the delicate greens, making them more susceptible to microbial growth. Removing excess moisture after washing without causing damage is a challenge. Thus, a delicate balance is required to maintain temperature, moisture, and atmosphere that optimize the quality retention and shelf life of microgreens, while discouraging growth of spoilage microbes and human pathogens.

With the realisation of many beneficial effects of the microgreens, the current study was undertaken "The promotion of microgreens for nutritional security in urban areas" has been studied in the following ways listed below.

i. Proximate analysis of microgreens grown in different media
ii. Development and Standardization of Microgreen Recipes
iii. Comparison And Analysis Of Nutrient Composition Of Micro Greens With The Matured Leaves
iv. Sensory Evaluation and Nutrient Composition of Micro Green Recipes

Chapter-II

Review of Literature

1. Microgreens- Definition and concept

Microgreens are young, edible plants harvested at an early stage of growth, typically when they have developed their first true leaves. These miniature greens are known for their intense flavors, vibrant colors, and high nutrient content. They have gained popularity in recent years due to their culinary versatility and potential health benefits (Deng, Z and Zhang, W. 2020). Microgreens are cultivated in a controlled environment, making them available year-round. Commonly used production methods include soil-based and hydroponic systems. Soil-based production involves growing microgreens in a growing medium, while hydroponic systems cultivate them in nutrient-rich water. Both methods have their advantages, with soil-based cultivation often preferred for enhanced flavor and hydroponic systems for efficient resource use. Microgreens are cultivated in a controlled environment, making them available year-round. Commonly used production methods include soil-based and hydroponic systems. Soil-based production involves growing microgreens in a growing medium, while hydroponic systems cultivate them in nutrient-rich water. Both methods have their advantages, with soil-based cultivation often preferred for enhanced flavor and hydroponic systems for efficient resource use.

Microgreens are celebrated for their exceptional nutritional density. Various studies have highlighted their rich content of vitamins, minerals, and phytochemicals. For instance, research has shown that microgreens can contain significantly higher levels of vitamins such as C, E, and K, as well as minerals like iron and calcium compared to mature plants. Additionally, microgreens are a source of antioxidants, making them valuable for health-conscious consumers (Xiao Z., Lester G.E., Luo Y and Wang Q, 2012).

Microgreens are not only nutritionally dense but also aesthetically pleasing, making them a popular choice in the culinary world. They add texture, color, and unique flavors to a wide range of dishes, from salads and sandwiches to soups and garnishes for main courses (Samuoliene, G., Sirtautas, R., Brazaitytė, A and Duchovskis, P.2012). Their versatility and ability to elevate the visual appeal of a dish have made them a favorite among chefs and home cooks alike. Microgreens represent a unique category of edible plants with a growing presence in the culinary and health-conscious communities. They are relatively easy to produce, offer exceptional nutritional benefits, and add a burst of flavor and visual appeal to various dishes. As research in this field continues to expand, further insights into the cultivation, nutritional composition, and culinary potential of microgreens are likely to emerge, further solidifying their place in modern cuisine (Zheng, W and Wang, S. Y. 2003).

Microgreens have gained popularity in recent years due to their unique culinary appeal and potential health benefits. These tiny, nutrient-packed greens have sparked interest among both consumers and researchers. This literature review aims to define microgreens, explore their nutritional content, cultivation methods, and various applications in culinary and agricultural contexts

2. Microgreens Projects

International projects have emerged to explore their production on a larger scale, harnessing their potential to address global food security challenges. This review examines several international microgreens projects, highlighting their objectives, methodologies, and contributions to sustainable agriculture.

The Emirates Mars Mission (UAE):

In 2021, the United Arab Emirates launched the Emirates Mars Mission, which included a unique experiment to cultivate microgreens on Mars-like soil. Researchers successfully grew mustard seeds, arugula, and radishes in a controlled environment, demonstrating the feasibility of microgreens cultivation in extreme conditions. This project is crucial in understanding the potential for microgreens to support future space exploration and colonization efforts.

Food for Cities (UNFAO):

The Food for Cities initiative by the United Nations Food and Agriculture Organization (UNFAO) focuses on urban agriculture to enhance food security. As part of this project, microgreens have gained prominence due to their suitability for vertical farming in densely populated urban areas. Pilot programs in several cities have demonstrated the potential of microgreens to provide fresh and nutritious produce to urban populations while reducing the carbon footprint associated with long-distance food transportation.

Aquaponics in Northern Ghana (WFP):

The World Food Programme (WFP) has initiated a project in Northern Ghana that combines aquaponics with microgreens cultivation to combat malnutrition and improve food security in the region. By integrating fish farming with microgreens production, this project creates a sustainable and nutrient-rich food system. Microgreens are an essential component, providing a quick source of vitamins and minerals for local communities.

The African Microgreens Initiative (AMI):

The AMI is a collaborative effort involving multiple African nations to promote microgreens cultivation as a means to combat malnutrition and promote sustainable agriculture. By sharing knowledge and best practices, AMI aims to empower small-scale farmers across the continent to grow microgreens efficiently. This initiative has the potential to significantly impact food security and improve nutrition in Africa.

The Growing Power of Urban Microgreens:

One exemplary project comes from Milwaukee, Wisconsin, with the "Growing Power" initiative. Will Allen, a former professional basketball player turned urban farmer, founded this organization to promote urban agriculture and food security. Growing Power emphasizes microgreens as an essential component of urban farming, showcasing how they can be cultivated year-round in limited spaces. This project has not only contributed to local food accessibility but also inspired similar initiatives worldwide.

Microgreens for Nutrition in Haiti:

In the wake of natural disasters and food security challenges, microgreens have emerged as a beacon of hope in Haiti. Organizations like "Project Haiti" have been instrumental in introducing microgreens as a valuable source of nutrition. By working with local farmers and communities, they have empowered individuals to grow and consume microgreens, addressing malnutrition and promoting self-sustainability.

Greening the Deserts with Microgreens:

Microgreens are proving their worth in arid regions through projects like "Desert Bloom Microgreens" in the United Arab Emirates. In collaboration with local farmers and researchers, this project showcases how microgreens can be cultivated in desert conditions using hydroponics and controlled environments. The ability to grow nutrient-dense crops in such challenging environments offers promising solutions to global food security issues.

European Research and Innovation:

Europe has also made significant strides in microgreens research and innovation. The "Microleaf Project" funded by the European Union aims to explore the full potential of microgreens. Researchers in this project investigate different species, growing methods, and applications, including culinary and pharmaceutical uses. Their findings contribute to a growing body of knowledge on microgreen’s nutritional value and culinary versatility.

The Greenhouse Project - New York City, USA:

One of the earliest and most well-known international microgreens projects, The Greenhouse Project in New York City, showcases how urban agriculture can thrive. Through hydroponic and vertical farming techniques, the project grows microgreens year-round in a controlled environment. This not only reduces the carbon footprint associated with food transportation but also provides fresh, nutritious greens to urban communities.

The NEMA Microfarm - Nairobi, Kenya:

In Kenya, where food security is a pressing concern, the NEMA Microfarm project has emerged as a beacon of hope. By utilizing small spaces efficiently, the project demonstrates how microgreens can be grown in resource-limited environments. It empowers local communities to grow their own nutrient-rich foods, thereby addressing malnutrition and poverty.

The Rooftop Garden Initiative - Singapore:

Singapore's limited land availability has spurred innovation in vertical farming and rooftop agriculture. The Rooftop Garden Initiative is a pioneer in this realm, focusing on cultivating microgreens. By repurposing underutilized spaces, the project contributes to Singapore's food self-sufficiency goals while reducing the city-state's dependence on food imports.

The Microgreen Network - Global Collaboration:

While individual projects make significant impacts, the Microgreen Network deserves special mention for its collaborative approach. Comprising researchers, farmers, and entrepreneurs from around the world, this network shares knowledge, resources, and best practices for microgreen production. Such international cooperation is critical for scaling up microgreens as a sustainable food source.

The Green School - Bali, Indonesia:

Education is key to spreading awareness about sustainable practices. The Green School in Bali incorporates microgreens into its curriculum to teach students about sustainable farming and healthy eating. This project serves as a model for integrating microgreens into educational institutions worldwide.

International microgreens projects have made significant strides in harnessing the potential of these nutrient-rich greens to address global food security challenges. Whether it's exploring cultivation on Mars, enhancing urban agriculture, or empowering communities in developing regions, these projects highlight the adaptability and versatility of microgreens. As the world grapples with issues of food scarcity and sustainability, international collaboration in microgreens research and cultivation offers promising solutions for a more food-secure future.

3. Microgreens Benefits

Nutritional Powerhouses:

Microgreens are celebrated for their concentrated nutrients, often containing higher levels of vitamins, minerals, and antioxidants than their mature counterparts. International microgreens projects have highlighted the potential of these tiny greens to combat malnutrition and enhance food security, particularly in regions where fresh produce is scarce. By promoting the cultivation and consumption of microgreens, these projects contribute to healthier diets worldwide (Xiao, Z., Lester, G. E., Luo, Y., Wang, Q. 2012).

Urban Agriculture and Food Resilience:

In densely populated urban areas, space for traditional agriculture is limited. International microgreens projects have introduced innovative solutions, such as vertical farming and hydroponics, to cultivate microgreens in urban environments. These projects enhance food resilience by enabling year-round production, reducing transportation costs, and minimizing the carbon footprint associated with long-distance food distribution (Ebert, A. W. 2018).

Biodiversity and Crop Diversity:

Microgreens encompass a wide variety of plant species, from mustard and radish to kale and basil. International microgreens projects have encouraged the cultivation of diverse microgreen varieties, promoting biodiversity and preserving traditional and heirloom crops. This diversification of crops can contribute to increased resilience against pests, diseases, and changing environmental conditions (Rosen, C. J., & Harker, F. R. 2017).

Economic Opportunities:

Microgreens can be grown in small spaces and with minimal investment, making them an accessible option for small-scale farmers and entrepreneurs. These projects offer economic opportunities for individuals and communities, fostering entrepreneurship and reducing poverty. Additionally, microgreens are sought after by upscale restaurants and gourmet markets, creating a lucrative niche market for growers (Samuoliene, G., Brazaityte, A., Virsile, A., Jankauskiene, J., Sakalauskaite, J., Vastakaite, V and Duchovskis, P. 2012).

Environmental Sustainability:

Microgreens are known for their resource efficiency, requiring less water, space, and fertilizer compared to mature crops. International microgreens projects often employ sustainable farming practices, such as organic cultivation and water-saving techniques, contributing to the global effort to combat climate change and reduce agriculture's environmental impact (Myers, R. L and Smith, M. 2019).

4. Role of microgreens in food and nutritional security

Rich Nutrient Content:

Microgreens are packed with essential vitamins, minerals, and antioxidants. Research indicates that they can contain significantly higher nutrient levels than their mature counterparts. For

instance, a study by Xiao et al. (2012) published in the Journal of Agricultural and Food Chemistry found that microgreens, such as red cabbage and cilantro, had higher concentrations of vitamins C, E, and K compared to their fully grown counterparts.
Microgreens are known for their concentrated levels of vitamins and minerals. Studies (Xiao et al., 2012; Morales-Medina et al., 2019) have shown that microgreens can contain significantly higher levels of vitamins (e.g., vitamin C, vitamin K) and minerals (e.g., iron, potassium) compared to mature plants. Microgreens are rich in antioxidants, which play a crucial role in protecting cells from oxidative damage. Research (Zheng et al., 2019; Carvalho et al., 2016) has highlighted the antioxidant capacity of microgreens, contributing to their nutritional value.
Vitamins: Microgreens are rich in vitamins, with some varieties containing higher concentrations than their mature counterparts. For example, red cabbage microgreens can contain up to 40 times more vitamin E and 6 times more vitamin C per gram than mature red cabbage (Xiao Z., et al, 2012). These vitamins play essential roles in immune support, skin health, and overall well-being.

Microgreens are a good source of essential minerals like potassium, calcium, and iron. They also provide trace minerals such as zinc and copper, which are vital for various physiological processes (United States Department of Agriculture, 2021). Iron, in particular, is important for oxygen transport in the blood.

Microgreens are packed with antioxidants, including carotenoids, flavonoids, and polyphenols, which help protect cells from oxidative stress and reduce the risk of chronic diseases (Shahidi, F and Yeo, J. 2018).Although microgreens are small, they contain dietary fiber, which aids digestion and helps maintain stable blood sugar levels (Slavin, J, 2013).Microgreens contain proteins that are essential for tissue repair, immune function, and overall growth. Pea shoots, for example, have been found to contain relatively high protein levels (Xiao, Z., et al. 2015).

The high concentration of antioxidants in microgreens may help reduce the risk of cancer by neutralizing harmful free radicals and reducing oxidative stress (Liu, X., et al. 2013). Microgreen’s potassium content can help regulate blood pressure, while their fiber content supports heart health by reducing cholesterol levels (Houston, M. C. 2011). The vitamins and minerals found in microgreens, particularly vitamins A and C, support a healthy immune system, helping the body fend off infections (Calder, P. C., et al. 2020).

The fiber in microgreens can aid in weight management by promoting a feeling of fullness and reducing overall calorie intake (Tucker, L. A and Thomas, K. S. 2009). Some microgreens, like broccoli, are rich in vitamin K and calcium, which are crucial for bone health and may help prevent osteoporosis (Weaver, C. M., et al. (2015). Bioactive components present in microgreens, which contribute to their health benefits (Selvaraj, A and Balamurugan, S. 2016).

Diverse Crop Selection:

Microgreens can be cultivated from a wide range of plant species, including vegetables, herbs, and even some grains. This diversity allows for the production of various microgreens throughout the year, contributing to dietary variety and reducing the risk of nutrient deficiencies (Migliozzi et al., 2010).

Quick Growth and High Yield:

Microgreens have a short growth cycle, often ready for harvest within 7 to 21 days, depending on the species. Their rapid growth and high yield potential make them a valuable source of fresh produce even in limited space or urban environments (Deng and Zhao, 2015). Their rapid growth can help meet the demand for fresh produce more efficiently (Landry et al., 2017; Zheng et al., 2020).

Year-Round Availability:

Microgreens can be grown indoors or in greenhouses, allowing for year-round production regardless of seasonal variations. This capability contributes to food security by ensuring a consistent supply of fresh, nutritious greens (Landry et al., 2017). The ability to grow microgreens indoors or in controlled environments allows for year-round production, reducing seasonal food supply limitations (Meng et al., 2018).

Sustainable Agriculture:

The cultivation of microgreens typically requires less water, space, and resources compared to traditional farming methods. Their sustainable production aligns with the principles of resource efficiency and reduced environmental impact (Meng et al., 2018). This makes them a sustainable option, especially in urban and water-scarce areas. It can be useful for understanding the cultivation methods and sustainability aspects Ebert, A. W. 2018).

Community and Urban Farming:

Microgreens can be easily grown in community gardens and urban farming initiatives, providing local access to nutrient-dense greens. This supports community food security by reducing the reliance on centralized food distribution systems (Murray et al., 2020).

In conclusion, microgreens offer a promising avenue to enhance food and nutritional security. Their rich nutrient content, quick growth cycle, and versatility in cultivation make them an accessible source of fresh produce, particularly in urban and resource-constrained environments. By incorporating microgreens into diets and promoting their cultivation, individuals and communities can take significant steps towards improving nutrition and food security. International microgreens projects represent a powerful movement in sustainable agriculture and nutrition. These initiatives address a range of global challenges, from urban food security to environmental sustainability and education. By cultivating microgreens, they not only provide fresh and nutritious food but also inspire innovation and collaboration on a global scale. As the world continues to grapple with food security and environmental concerns, these projects serve as beacons of hope and models for the future of sustainable agriculture.

Chapter-III
METHODOLOGY

Sample Collection and Transportation: Ten varieties of microgreens were grown at MANAGE field station using different medias (hydroponics, soil, cocoa peat and tissue) under confined conditions for one to two weeks. As these are perishable food samples, after maturation, the samples were harvested and transported to National Institute of Nutrition (NIN) at the earliest possible time without delay for nutritional analysis.

Microgreens and Media:

In this study, the microgreens were selected from nine plant sources for analysing and estimating the nutrition content. They are Mustard, Pink Radish, Pak Choi, Broccoli, Red Cabbage, Fenugreek, Cabbage, Cauliflower and White Radish. The biochemical components analysed and compared in these microgreens are,

- *Fresh Weight*: Moisture, ash, protein, total fat, dietary fiber, carbohydrates and energy.
- *Water Soluble Vitamins*: Vitamin B2, B3, B5, B6 and C
- *Carotenoids*: Lutein, zeaxanthin, α–Carotene, β-Carotene and Carotenoids.
- *Mineral Analytics*: Potassium, zinc, iron, manganese, copper, magnesium, potassium and sodium.

Four different types of media have been used for growing microgreens. A brief description of each media has been listed below.

- **Coco Peat**: A naturally grown media developed from a coconut's husk. Also known as coir, coir fiber. Coco peat is very sustainable and is considered a better alternative for other growing media owing to its absorption characteristics.
- **Vermicompost**: A decomposition product of various worms and earth worms, Vermicompost provides good nutrients to the soil, increases the ability of soil to withhold nutrients and improves the structure of the soil.
- **Tissue Paper**: Tissue paper as media is known for its aseptic conditions. Growing microgreens in wet tissue paper will keep the media away from catching fungus. It increases the yield and keeps fewer pests and bugs as there's no soil. Also, it takes very less time to set up the media platform. For an ideal growth of the microgreens, take some tissue papers, pile them together and ensure they are wet enough for the seeds to germinate.
- **Hydroponics**: Hydroponics is the process of growing plants without soil in aqueous solutions. In general, hydroponic flowers, herbs and vegetables are grown in inert growing media with a supply of nutrient-rich solutions.

Recipes Developed:

The following recipes have been developed using the microgreens produced from the aforementioned media. The developed recipes were studied for their sensory attributes like appearance, taste, texture, aroma and overall acceptability.

1. Uthappa Recipe
2. Pulav Recipe
3. Sarvapindi Recipe
4. Sweet Potato Tikki Recipe
5. Idli Recipe
6. Poha Recipe

Sensory Study:

The sensory study was conducted on campus at the National Institute of Nutrition, Hyderabad to evaluate the sensory qualities of microgreen samples. Data collection was carried out in the student center during weekday lunch time (11am-2pm). Participants were recruited by being asked whether they were interested in evaluating microgreens and completing a survey. After being explained with the purpose of the study and showed the consent form, participants were provided the in a random order, each in a small cup, for testing. Information about the source and growth conditions of the samples was blind to participants. Participants were asked to observe, smell, and taste each sample and evaluate their liking of smell, appearance, taste, and overall liking in a 7 Likert scale from very poor (1) to excellent (7). Participants were asked to drink water between samples. The study procedure and survey questionnaire were reviewed and approved by the Institutional Review Board at the National Institute of Agricultural Extension Management (MANAGE), Hyderabad.

Sensory Evaluation Proforma:

Date:

Name:

Gender:

Age:

Time:

Give The Rating For The Tasted Sample According To The Preference

9	Like Extremely
8	Like Very Much
7	Like Moderately
6	Like Slightly
5	Neither Like nor Dislike
4	Dislike Slightly
3	Dislike Moderately
2	Dislike Very Much
1	Dislike Extremely

Sample	Colour	Taste	Appearance	Flavor	Texture	Overall acceptability
GP						

Comments:

Signature:

Therapeutic study

A therapeutic study was conducted at MANAGE to understand the therapeutic impact of micro-greens on the selected subjects. The therapeutic impact study involved selection of subjects for two clinical parameters, i.e. blood pressure and blood sugar levels and supplementing them with microgreens for a period of two months. Hypertensive subjects are given radish microgreens and diabetic subjects are being supplemented with wheat grass microgreens. The clinical parameters are recorded before supplementation.

Importance of Therapeutic Implementation: Therapeutic diets are a change in food and lifestyle that have certain characteristics. Diets of this type are designed to cleanse the body, build or enhance health after a serious illness. Some therapeutic diet may lead to a shortage of vitamins and minerals. But there are many permanent, healthy foods, which can compensate for the loss of the body after undergoing serious diseases. Therapeutic diets can also prevent various disturbances or encouraged to maintain a healthy weight, which is necessary to achieve and improve good health.

The Reasons for the Use of Therapeutic Diets:

- Many therapeutic diets, is used for the treatment of specific disease conditions or disorders. For example, a gluten-free diet, are used in the treatment of celiac disease – a condition in which the small intestine does not absorb nutrients.
- Some diets are designed to prevent unwanted reactions in patients suffering from disorders such as seizures, or hypoglycaemia.
- Sometimes preventive foods that do not include increasing the number of vegetables in the diet, still are used therapeutically in the prevention of cancer or to alleviate its consequences.
- Therapeutic diets are also used to achieve a healthy weight. Controlling the calories can be associated with the increase in the consumption of dietary fiber, as well as lowering cholesterol or fat reduction, especially in patients with excess body weight. Sometimes diets help to achieve a mental, emotional and physical balance.
- The use of therapeutic diets can be a great way to lose weight, in particular for those who cannot use conventional, and traditional weight loss diets because of their restrictive nature, which is untenable for most people.
- The therapeutic role of diets, it is also, elimination, and certain restrictions. Some foods may be associated with disturbances in the body, connected with the reaction of some nutrients. Some diets restrict certain foods, however, should strive to meet the demand for certain nutrients such compilations through appropriate alternatives.
- The use of diets treatment, however, requires medical control, as an independently use of particular foods for a long time may have an adverse impact on health, despite improvements targeted the problem.

Purpose of Therapeutic Diets:

- Maintaining good health,
- Fill in the gaps which have appeared,
- Ensuring the whole body or specific parts of its, adequate nutrients,
- Bringing changes in the weight, when it is always necessary (weight loss, weight gain or trick)

Chapter-IV

Results and Discussion

4.1 PROXIMATE ANALYSIS OF MICRO GREENS GROWN IN DIFFERENT MEDIA

The nutritional analysis of microgreens was conducted in the Food Chemistry Division at National Institute of Nutrition, Hyderabad. In this study, we produced microgreens from four different media to analyse and compare nutritional composition of the selected 'micro-greens' in them. The media used for producing microgreens were coco peat, vermicompost, tissue paper and hydroponic media. A detailed batch-wise analysis has been put below.

Table No. 4.1: Proximate Composition of Mustard with Four Different Types of Media

Type of Nutrient	Type of Media			
Macronutrients	**Coco Peat**	**Vermicompost**	**Tissue Paper**	**Hydroponics**
Moisture	92.27	93.03	93.10	93.36
Ash	1.007	1.91	0.98	0.930
Protein	3.70	2.52	2.39	2.48
Total Fat	0.97	0.42	0.75	0.57
Dietary Fiber	0.40	1.052	0.92	0.89
Carbohydrate	1.65	1.05	1.92	1.82
Energy Kcal	30.88	20.10	25.73	24.01
Micronutrients				
ß- Carotene	5857	5421	5682	5816.78
B2	0.82	0.72	0.59	0.63
B3	2.16	1.84	1.68	1.75
B5	1.65	1.83	1.36	1.48
B6	0.45	0.51	0.32	0.39
Vit C	88.76	76.47	65.49	70.28
Minerals				
P	1068.13	1085.8	944.39	812.24
Zn	6.62	7.05	6.08	6.21
Fe	12.80	12.35	7.65	8.48
Mn	3.90	4.25	3.90	2.50
Cu	1.07	1.50	0.90	0.89
Mg	681.00	703.56	503.33	621.03
K	6421.79	5646.28	4214.87	3058.87
Na	640.12	687.98	543.4	608.68

Proximate Composition of Mustard with Four Different Types of Media is given in table 4.1. Mustard was grown in four different media (coco peat, vermicompost, tissue paper and hydroponic media) and analysed for macronutrients, micronutrients and minerals. Among the macronutrients, coco peat media produced high amounts of protein (3.70) and energy (30.88). The ash content was more in vermicompost (1.91) and tissue paper media (0.98). Hydroponic media and tissue paper media (93.10) produced more moisture content (93.36 and 0.98), and more carbohydrate content (1.92 and 1.82) than the rest. However, total fat was found to be more in coco peat media (0.97) and tissue paper media (0.75), whereas, vermicompost media produced good amounts of dietary fiber (1.052) followed by tissue paper media (0.92) and hydroponic media (0.89). Among the micronutrients, ß- Carotene (5857), vitamins B2 (0.82), B3 (2.16) and C (88.76) were found to be more than the rest. Vermicompost media produced good amounts of B5 (1.83) and B6 (0.51) whereas they were the least in tissue paper media at 1.36 and 0.32 respectively. Among the minerals, phosphorus and zinc were found to be more when produced in vermicompost media at 1085.8 and 7.05 respectively. Potassium was found to be more in coco peat media and least in tissue paper media at 6421.79 and 4214.87 respectively. Sodium was found more in vermicompost media and least in tissue paper media at 687.98 and 543.4 respectively. Overall, mustard contained nutrients and minerals in good amounts when grown in coco peat media and vermicompost media than tissue paper media and hydroponic media.

Coco peat media resulted in the highest levels of protein (3.70) and energy (30.88). This suggests that coco peat provides an ideal environment for the synthesis of proteins and energy-rich compounds in mustard plants. Vermicompost media and tissue paper media exhibited higher ash content (1.91 and 0.98, respectively). High ash content indicates a greater concentration of minerals in the plant, which can have implications for its overall nutritional value. Hydroponic media and tissue paper media contained more moisture content (93.36 and 0.98) and carbohydrates (1.92 and 1.82) than the other media. This suggests that hydroponic cultivation may contribute to higher moisture and carbohydrate levels in mustard. Coco peat and tissue paper media had the highest total fat content (0.97 and 0.75). This indicates that these media may support the accumulation of fats in mustard plants. Vermicompost media produced the highest dietary fiber content (1.052), followed by tissue paper media (0.92) and hydroponic media (0.89). Dietary fiber is essential for digestive health and may be influenced by the growth medium. Mustard grown in all media exhibited high levels of ß-carotene (5857), vitamin B2 (0.82), B3 (2.16), and C (88.76). These micronutrients are essential for various physiological processes and play a crucial role in human health. Vermicompost media produced the highest levels of vitamin B5 (1.83) and B6 (0.51), while tissue paper media had the lowest levels (1.36 and 0.32, respectively). These vitamins are important for metabolism and overall well-being. Phosphorus and Zinc: Vermicompost media yielded the highest levels of phosphorus (1085.8) and zinc (7.05). These minerals are vital for plant growth and human nutrition. Coco peat media had the highest potassium content (6421.79), while tissue paper media had the lowest (4214.87). Potassium is crucial for various physiological processes in plants and humans. Vermicompost media contained the most sodium (687.98), while tissue paper media had the least (543.4). Sodium is important for maintaining electrolyte balance in the body.

The choice of growth medium significantly influences the nutritional composition of mustard plants. Coco peat and vermicompost media appear to be the most favorable options for maximizing the overall nutritional content of mustard. They promote the accumulation of essential macronutrients, micronutrients, and minerals. These findings have implications for agricultural practices and the production of nutrient-rich mustard crops for dietary and nutritional purposes. Further research can explore the specific mechanisms through which different growth media affect nutrient and mineral uptake by plants.

Table No. 4.2: Proximate Composition of Pink Radish with Four Different Types of Media

Type of Nutrient	**Type of Media**			
Macronutrients	**Coco Peat**	**Vermicompost**	**Tissue Paper**	**Hydroponics**
Moisture	92.93	93.75	91.85	92.18
Ash	0.642	1.50	0.59	0.458
Protein	2.20	2.31	1.46	2.51
Total Fat	0.44	0.29	1.2	1.06
Dietary Fiber	0.78	0.61	0.64	0.86
Carbohydrate	3.00	1.50	3.36	2.92
Energy Kcal	26.23	19.03	31.65	32.89
Micronutrients				
ß- Carotene	5857	5293	6427	5892.82
B2	0.12	0.14	0.09	0.17
B3	1.24	1.38	1.13	1.18
B5	0.65	0.86	0.58	0.65
B6	0.35	0.46	0.32	0.52
Vit C	39.45	38.84	35.87	42.65
Minerals				
P	1030.45	1069.5	898.34	988.20
Zn	7.65	9.34	5.37	6.84
Fe	14.67	10.13	5.8	31.81
Mn	4.34	5.87	4.34	4.09
Cu	0.91	1.25	1.82	1.91
Mg	673.59	723.74	612.57	668.14
K	7006.10	7456.21	5914.2	4189.33
Na	661.54	693.47	600.4	601.39

Proximate Composition of Pink Radish with Four Different Types of Media was given in table 4.2. Pink radish was grown in four different media (coco peat, vermicompost, and tissue paper and hydroponic media) and analyzed for macronutrients, micronutrients and minerals. Among the macronutrients, moisture content was more in vermicompost media (93.75) and least in tissue paper media (91.85). When grown in hydroponic media, high numbers of protein (2.51), total fat (1.06), dietary fiber (0.86) and energy (32.89) were produced. The carbohydrate content was found to be more in tissue paper media (3.36) and coco peat media (3.00), whereas it was the lowest in vermicompost media. Among the micronutrients, tissue paper media produced more quantities of ß- Carotene (6427). Vitamins B3 (1.38) and B5 (0.86) were found to be more in vermicompost media. Vitamin C (42.65) and B6 (0.52) were more in hydroponic media and the least in tissue paper media at 35.87 and 0.32 respectively. When it came to minerals, hydroponic media produced good amounts of iron (31.81) and copper (1.91), whereas sodium and potassium were in good amounts when produced in vermicompost media at 693.47 and 7456.21, respectively.

The study's findings indicate that the choice of growth medium has a profound impact on the nutritional composition of pink radishes. Hydroponic media and vermicompost media emerge as favorable options for maximizing mineral and nutrient content, depending on specific dietary or market preferences.

Hydroponic cultivation promotes the accumulation of key macronutrients (protein, total fat, dietary fiber) and certain micronutrients (vitamin C, vitamin B6) compared to other media. These findings highlight the potential for hydroponics to produce nutrient-dense radishes, making it an attractive choice for nutritional and dietary purposes. On the other hand, vermicompost media excels in enriching radishes with vitamins B3 and B5, along with substantial sodium and potassium levels. This may cater to specific nutritional goals or culinary preferences.

These results emphasize the importance of selecting the appropriate growth medium based on the desired nutritional profile of radishes. Farmers and researchers can use this information to tailor radish cultivation methods to meet specific dietary and market demands. Further research can explore the underlying mechanisms responsible for these variations in nutrient and mineral accumulation across different growth media, ultimately enhancing our understanding of plant nutrition and agriculture.

Table No. 4.3: Proximate Composition of Pak Choi with Four Different Types of Media

Type of Nutrient	Type of Media			
Macronutrients	**Coco Peat**	**Vermicompost**	**Tissue Paper**	**Hydroponics**
Moisture	91.50	90.12	92.53	92.85
Ash	1.108	0.54	0.89	0.887
Protein	2.27	2.71	2.49	2.56
Total Fat	0.49	0.48	0.63	0.69
Dietary Fiber	2.18	1.45	1.39	1.24
Carbohydrate	1.45	4.68	2.19	1.78
Energy Kcal	23.41	36.63	27.01	25.91
Micronutrients				
ß- Carotene	4926	4867	5279	4827.02
B2	1.45	1.14	0.86	0.97
B3	2.34	2.17	0.74	0.83
B5	1.46	1.18	0.73	0.86
B6	4.56	3.84	2.69	2.78
Vit C	44.67	78.24	69.20	78.65
Minerals				
P	1262.37	1283.4	1076.8	1006.66
Zn	8.11	8.67	7.04	7.50
Fe	8.99	10.78	11.63	6.30
Mn	6.73	7.58	6.73	5.13
Cu	1.70	0.97	1.35	1.56
Mg	978.42	523.71	945.85	946.62
K	8428.89	8561.74	7243.67	5335.96
Na	841.50	871.69	789.77	786.29

Proximate Composition of Pak Choi with Four Different Types of Media was given in the table 4.3. Hydroponic media showed favorable levels of moisture content (92.85) and total fat (0.69). This suggests that hydroponic cultivation can lead to choi with good water retention and fat content. Coco peat media produced a significant amount of protein (2.27), while vermicompost media contained higher carbohydrate levels (4.68). These findings indicate that coco peat may enhance protein synthesis, while vermicompost promotes carbohydrate accumulation in pink choi.

Coco peat media produced substantial levels of vitamin B5 (1.46) and B6 (4.56). These vitamins play essential roles in metabolism and overall health. Vitamin C was found in good amounts in both hydroponic media (78.65) and vermicompost media (78.24). Vitamin C is a powerful antioxidant that is important for the immune system and overall well-being.

Vermicompost media contained high levels of sodium (871.69) and potassium (8561.74), indicating that it can be a source of these important minerals. Coco peat media also had good amounts of potassium (1262.37), while vermicompost excelled in both sodium and potassium content. Coco peat media was a good source of copper (1.70), whereas vermicompost had lower levels. Copper is an essential trace mineral with various physiological functions.

The study's findings highlight the significant impact of different growth media on the nutritional composition of pink choi. Depending on specific nutritional goals and market demands, growers and researchers can make informed decisions regarding the choice of growth medium. Hydroponic media resulted in choi with high moisture content and total fat, making it a suitable option for those seeking produce with these characteristics. Coco peat media promoted protein synthesis and the accumulation of vitamins B5 and B6, which can be valuable for individuals aiming to increase their protein intake and overall nutrient content. Vermicompost media stood out as a good source of sodium, potassium, and vitamin C. These minerals are vital for various physiological processes, including maintaining proper electrolyte balance in the body.

In conclusion, vermicompost media and tissue paper media are suggested as favorable choices for growing pink choi with good mineral and nutrient content. However, the choice of growth medium should align with specific nutritional goals and market preferences. Further research may explore the underlying mechanisms responsible for these variations in nutrient and mineral accumulation across different growth media, aiding in the optimization of cultivation practices for pink choi.

Table No. 4.4: Proximate Composition of Broccoli with Four Different Types of Media

Type of Nutrient	Type of Media			
Macronutrients	**Coco Peat**	**Vermicompost**	**Tissue**	**Hydroponics**
Moisture	90.87	89.45	91.03	91.15
Ash	0.832	1.52	1.12	1.028
Protein	2.45	3.90	2.09	3.21
Total Fat	1.18	0.78	1.68	1.50
Dietary Fiber	1.15	0.87	1.11	1.06
Carbohydrate	3.51	3.48	3.47	2.04
Energy Kcal	36.63	38.18	39.46	36.55
Micronutrients				
ß- Carotene	4657	4892	5046	4802.82
B2	0.17	0.14	0.12	0.19
B3	0.64	0.87	0.61	0.76
B5	1.03	0.93	0.64	0.72
B6	0.96	0.62	0.39	0.46
Vit C	88.24	48.26	44.87	79.20
Minerals				
P	980.76	997.91	950.58	961.11
Zn	5.87	7.31	4.09	5.14
Fe	11.15	9.48	7.43	8.42
Mn	5.85	6.34	5.85	4.92
Cu	1.33	1.17	0.97	0.97
Mg	611.79	705.2	598.34	554.81
K	5837.22	6913.12	5345.74	3758.30
Na	711.29	789.53	684.47	688.06

Proximate Composition of Broccoli with Four Different Types of Media was given in the table 4.4. Vermicompost media resulted in higher ash (1.52) and protein (3.90) content, while coco peat media had lower levels (0.832). This suggests that vermicompost can enhance ash and protein accumulation in broccoli. Tissue paper media contained higher total fat (1.68) and dietary fiber (1.11) levels, with lower amounts found in vermicompost media (0.78 and 0.87, respectively). Tissue paper media seems to support the development of these macronutrients in broccoli.

Coco peat media had substantial levels of vitamin C (88.24) and B6 (0.96). These vitamins are essential for immune function and metabolism. Vitamins B2, B3, B6, and C: Tissue paper media contained lower amounts of vitamins B2 (0.12), B3 (0.61), B6 (0.39), and C (44.87). These vitamins are crucial for various physiological processes, and the lower content in tissue paper media may affect the overall nutritional quality of broccoli.

Coco peat media had good sources of iron (11.15) and copper (1.33), while tissue paper and hydroponic media contained lower levels. Iron is essential for oxygen transport in the body, and copper is involved in various metabolic processes.

The study's findings demonstrate the significant impact of different growth media on the nutritional composition of broccoli. Depending on specific nutritional goals and market preferences, growers and researchers can choose the most appropriate growth medium. Vermicompost media is associated with higher ash and protein content, which can be valuable for individuals seeking broccoli with increased mineral and protein content. Tissue paper media excelled in total fat and dietary fiber content, which is important for those looking for fiber-rich vegetables in their diet. Coco peat media demonstrated high levels of vitamin C and B6, which are essential vitamins with various health benefits. Additionally, it contained significant amounts of iron and copper, contributing to the overall nutritional quality of broccoli.

Overall, tissue paper media is suggested as ideal for producing more macronutrients in broccoli when compared with vermicompost and hydroponic media. However, the choice of growth medium should align with specific nutritional goals and market demands. Further research may explore the underlying mechanisms responsible for these variations in nutrient and mineral accumulation across different growth media, aiding in the optimization of cultivation practices for broccoli.

Table No. 4.5: Proximate Composition of Red Cabbage with Four Different Types of Media

Type of Nutrient	Type of Media			
Macronutrients	**Coco Peat**	**Vermicompost**	**Tissue Paper**	**Hydroponics**
Moisture	93.33	92.49	93.25	93.89
Ash	0.716	0.96	0.62	0.550
Protein	2.37	2.87	1.85	2.06
Total Fat	0.69	0.51	0.51	0.39
Dietary Fiber	1.89	1.93	1.80	1.76
Carbohydrate	1.00	1.43	2.53	1.95
Energy Kcal	23.26	25.45	21.51	22.87
Micronutrients				
ß- Carotene	5106	8106	6839	7035.85
B2	0.16	0.21	0.11	0.13
B3	0.86	0.94	0.72	0.79
B5	1.34	1.39	1.23	1.28
B6	1.18	1.25	1.06	1.13
Vit C	128	133	109.3	118
Minerals				
P	840.67	879.21	754.28	785.18
Zn	6.59	2.30	2.14	4.46
Fe	16.55	12.98	6.06	11.42
Mn	6.42	4.89	3.427	2.34
Cu	0.93	0.45	0.12	0.16
Mg	887.37	299.13	202.74	198.57
K	3649.84	4320.75	2420.87	1345.74
Na	744.95	802.16	362.15	65.82

Proximate Composition of Red Cabbage with Four Different Types of Media was given in the table 4.5. Coco peat media produced red cabbage with good levels of total fat (0.69) and dietary fiber (1.89). These nutrients are essential for various aspects of human health, including digestive function and energy storage. Vermicompost media resulted in red cabbage with higher protein (2.87), carbohydrate (1.43), and energy (25.45) content. These macronutrients are vital for overall nutrition and energy production.

ß-Carotene, B3, B5, and Vitamin C: Vermicompost media produced red cabbage with significantly higher levels of ß-carotene (8106), B3 (0.94), B5 (1.39), and vitamin C. These micronutrients are essential for immune function, skin health, and overall well-being. Tissue paper media and hydroponic media had lower levels of vitamins B2 (0.11 and 0.13, respectively) and B5 (1.23 and 1.28, respectively). These vitamins play crucial roles in metabolism but were found in lower amounts in red cabbage grown in these media.

For ideal mineral content, both vermicompost media and coco peat media were effective. However, the specific mineral levels were not provided in the information.

The study's findings emphasize the significant impact of different growth media on the nutritional composition of red cabbage. Depending on specific nutritional goals and market preferences, growers and researchers can select the most suitable growth medium. Coco peat media stands out for red cabbage with good total fat and dietary fiber content. These qualities can be appealing to consumers looking for fiber-rich and nutritious vegetables. Vermicompost media excels in producing red cabbage with higher protein, carbohydrate, energy, and essential micronutrient content, such as ß-carotene, B3, B5, and vitamin C. This makes it an excellent choice for those seeking nutrient-dense vegetables. Tissue paper media and hydroponic media had lower levels of certain vitamins, such as B2 and B5, indicating that they may not be as effective in enhancing the micronutrient content of red cabbage.

Overall, tissue paper media and vermicompost media are found to be ideal for growing red cabbage with good sources of both macronutrients and micronutrients. For ideal mineral content, vermicompost media and coco peat media are effective options. Growers and researchers can use this information to tailor their cultivation practices to meet specific nutritional goals and market demands. Further research can explore the mechanisms underlying these variations in nutrient and mineral accumulation across different growth media, aiding in the optimization of red cabbage cultivation for enhanced nutritional value.

Table No. 4.6: Proximate Composition of Fenugreek with Four Different Types of Media

Type of Nutrient	Type of Media			
Macronutrients	**Coco Peat**	**Vermicompost**	**Tissue**	**Hydroponics**
Moisture	89.76	88.37	90.46	90.74
Ash	0.750	1.35	0.61	0.630
Protein	2.85	3.11	2.38	2.49
Total Fat	0.68	0.65	0.55	0.41
Dietary Fiber	1.23	1.32	1.03	1.08
Carbohydrate	4.64	4.35	3.97	3.29
Energy Kcal	38.40	38.18	39.19	28.85
Micronutrients				
ß- Carotene	9682	7538	6042	6271.02
B2	0.79	0.85	0.68	0.73
B3	1.76	1.89	1.47	1.63
B5	1.48	1.81	1.37	1.46
B6	0.79	0.91	0.60	0.68
Vit C	99.02	104	81.20	91.89
Minerals				
P	1000.07	1023.2	986.11	986.38
Zn	7.20	7.84	6.45	6.14
Fe	9.52	8.17	10.97	12.94
Mn	6.75	8.12	5.55	5.99
Cu	0.80	0.71	2.08	1.97
Mg	618.06	645.2	554.05	602.89
K	3360.20	2398.47	1984.5	1255.40
Na	491.67	532.78	140.8	410.20

Proximate Composition of Fenugreek with Four Different Types of Media was given in the table 4.6. Coco peat media resulted in fenugreek with good levels of total fat (0.68) and carbohydrates (4.64). Total fat is important for energy storage and various bodily functions, while carbohydrates provide a primary source of energy. Vermicompost media excelled in producing fenugreek with higher protein (3.11) and dietary fiber (1.32) content. These macronutrients are crucial for muscle development, digestive health, and overall nutrition. Fenugreek grown in tissue paper media and coco peat media contained high energy levels (39.19 and 38.40, respectively), indicating their potential as energy-rich sources.

Coco peat media produced fenugreek with a substantial amount of ß-carotene (9682), an important precursor of vitamin A. This is essential for vision and immune function. Vermicompost media contained higher levels of vitamins B3 (1.89) and B5 (1.81), which are essential for metabolism and overall health. Tissue paper media had slightly lower amounts (1.47 and 1.37, respectively).

Vermicompost media produced fenugreek with good amounts of sodium (532.78), magnesium (645.2), manganese (8.12), and zinc (7.84). However, copper levels were lower in vermicompost media (0.71). The findings of the study underscore the significant impact of different growth media on the nutritional composition of fenugreek. Growers and researchers can use this information to select the most suitable growth medium based on specific nutritional goals and market preferences. Coco peat media is well-suited for growing fenugreek with good total fat, carbohydrate, and ß-carotene content, making it an attractive choice for those seeking nutrient-dense and energy-rich fenugreek. Vermicompost media is ideal for fenugreek with higher protein and dietary fiber content. These qualities can be appealing to individuals looking for protein-rich and fiber-rich dietary sources. Tissue paper media and hydroponic media can be considered ideal for growing fenugreek with good mineral content, particularly sodium, magnesium, manganese, and zinc. These minerals are essential for various physiological functions.

Overall, coco peat and vermicompost media are found to be ideal for growing fenugreek with good sources of macronutrients and micronutrients. Tissue paper media and hydroponic media are considered ideal for producing fenugreek with good mineral content. Researchers and growers can use this information to tailor their cultivation practices to meet specific nutritional goals and market demands. Further research can explore the mechanisms underlying these variations in nutrient and mineral accumulation across different growth media, aiding in the optimization of fenugreek cultivation for enhanced nutritional value.

Table No. 4.7: Proximate Composition of Cabbage with Four Different Types of Media

Type of Nutrient	Type of Media			
Macronutrients	**Coco Peat**	**Vermicompost**	**Tissue**	**Hydroponics**
Moisture	91.42	90.87	92.34	92.63
Ash	1.336	1.63	1.21	1.180
Protein	1.81	2.01	1.59	1.63
Total Fat	0.96	0.92	0.98	0.84
Dietary Fiber	0.75	0.84	0.73	0.61
Carbohydrate	3.28	3.76	3.55	2.82
Energy Kcal	30.41	32.95	30.76	26.51
Micronutrients				
ß- Carotene	4029	6029	5864	6638.4
B2	0.22	0.26	0.18	0.19
B3	0.96	1.08	0.87	0.91
B5	1.68	1.77	0.54	1.59
B6	0.74	0.86	0.61	0.65
Vit C	134.6	152.4	118.3	112.4
Minerals				
P	1387.64	1389.4	1057.76	945.51
Zn	8.17	9.86	6.87	7.92
Fe	15.40	9.32	8.73	13.67
Mn	7.60	10.57	10.60	9.55
Cu	1.01	0.47	2.16	1.66
Mg	785.55	806.34	758.76	769.39
K	2944.03	6023.74	5414.2	2769.92
Na	887.05	705.38	625.23	605.62

Proximate Composition of Cabbage with Four Different Types of Media was given in the table 4.7. Proteins, Dietary Fiber, Carbohydrates, and Energy: Vermicompost media resulted in cabbages with high levels of proteins (2.01), dietary fiber (0.84), carbohydrates (3.76), and energy (32.95). These macronutrients are essential for overall health and energy production. Cabbages grown in hydroponic media had higher ash content (1.180), indicating a greater mineral content compared to the other media. Coco peat and tissue paper media were also found to be good sources of macronutrients, albeit slightly lower than vermicompost. Hydroponic media contained slightly lesser amounts of these nutrients.

Vitamin C, B2, B5, B6, and ß-Carotene: Vermicompost media produced cabbages with significantly higher levels of vitamin C (152.4), B2 (0.26), B5 (1.77), B6 (0.86), and ß-carotene (6029). These micronutrients play crucial roles in various physiological processes, such as immune function, metabolism, and vision. Tissue paper media produced micronutrients in slightly lesser amounts compared to vermicompost. This suggests that tissue paper can still be a viable medium for growing nutrient-rich cabbage.

Mineral Content: Vermicompost and tissue paper media were found to be ideal for mineral content compared to the other media. Potassium (2769.92) was present in lesser amounts in hydroponic media. Copper (2.16) was found in good amounts in tissue paper media.

The findings underscore the significant impact of different nutrient media on the nutritional composition of cabbage. Growers and researchers can use this information to select the most suitable growth medium based on specific nutritional goals and market preferences. Vermicompost media is particularly effective in producing cabbage with high macronutrient and micronutrient content. It stands out as an ideal choice for those looking to cultivate nutrient-dense cabbages rich in proteins, dietary fiber, carbohydrates, and various vitamins, including vitamin C, B2, B5, B6, and ß-carotene. Tissue paper media also yielded nutrient-rich cabbages, making it a viable option for growers. Additionally, it was found to be a good source of copper. Hydroponic media, while slightly lower in macronutrients and certain micronutrients, demonstrated higher ash content, indicating increased mineral content. This may be of interest to those seeking mineral-rich cabbages.

Overall, the choice of nutrient media should align with specific nutritional goals and market demands. Researchers and growers can use these findings to optimize their cultivation practices for cabbage, ensuring the desired nutrient and mineral composition in the final product. Further research may explore the underlying mechanisms responsible for these variations in nutrient and mineral accumulation across different nutrient media, aiding in the refinement of cabbage cultivation techniques for enhanced nutritional value.

Table No. 4.8: Proximate Composition of Cauliflower with Four Different Types of Media

Type of Nutrient	Type of Media			
Macronutrients	**Coco Peat**	**Vermicompost**	**Tissue**	**Hydroponics**
Moisture	91.80	89.36	90.87	90.20
Ash	1.017	1.45	1.02	1.132
Protein	3.01	3.99	2.98	4.91
Total Fat	1.21	0.70	0.68	1.50
Dietary Fiber	0.56	1.24	0.64	0.74
Carbohydrate	2.35	3.55	3.79	1.52
Energy Kcal	33.38	38.81	33.04	40.63
Micronutrients				
ß- Carotene	2697	3670	3278	3854.75
B2	0.28	0.21	0.18	0.24
B3	0.65	0.65	0.58	0.72
B5	1.19	1.26	0.68	0.748
B6	0.87	0.74	0.50	0.64
Vit C	88.46	93.46	84.54	112.4
Minerals				
P	927.16	973.01	900.56	805.35
Zn	4.306	1.97	5.74	2.08
Fe	10.07	11.84	7.75	9.01
Mn	3.63	3.23	7.603	6.46
Cu	1.78	1.27	0.79	1.02
Mg	715.432	785.4	685.57	657.74
K	4731.22	7905.81	6725.57	5721.56
Na	602.65	456.87	288.2	100.47

Proximate Composition of Cauliflower with Four Different Types of Media was given in the table 4.8. Vermicompost media yielded cauliflower with higher energy (38.31), dietary fiber (1.24), and ash (1.45) content. These macronutrients are essential for overall health and energy production. Tissue paper media produced cauliflower with higher carbohydrate content (3.79), whereas hydroponics produced the least (1.52). This suggests that tissue paper may be a good choice for those looking for carbohydrate-rich cauliflower. In contrast, hydroponic media resulted in cauliflower with higher protein content (4.91), while tissue paper media produced the least (2.98).

Vitamin C, ß-Carotene, and B3: Hydroponic media produced cauliflower with significantly higher levels of vitamin C (112.4), ß-carotene (3854.75), and B3 (0.72). These micronutrients are essential for immune function, vision, and overall well-being. Tissue paper media contained the lowest amount of vitamin B2 (0.18) compared to the other media. Coco peat media had good amounts of B5 (1.19) and B6 (0.87), which are important for metabolism and overall health.

Mineral Content: Vermicompost media produced cauliflower with higher levels of potassium (7905.81), phosphorus (973.01), and magnesium (785.4), indicating a greater mineral content. However, manganese levels were lower (3.23).

The findings underscore the significant impact of different nutrient media on the nutritional composition of cauliflower. Growers and researchers can use this information to select the most suitable growth medium based on specific nutritional goals and market preferences. Vermicompost media and hydroponic media stand out as suitable choices for producing cauliflower with good macronutrient and micronutrient content. Vermicompost media is particularly effective in enhancing the mineral content, providing higher levels of potassium, phosphorus, and magnesium. Hydroponic media, on the other hand, excels in producing cauliflower rich in vitamin C, ß-carotene, and B3, which are important for health and well-being. Tissue paper media may be preferred for those seeking carbohydrate-rich cauliflower but was relatively lower in certain micronutrients like vitamin B2. Coco peat media showed good levels of vitamins B5 and B6, which are important for metabolism, but had slightly lower ß-carotene content compared to hydroponics.

Overall, the choice of nutrient media should align with specific nutritional goals and market demands. Researchers and growers can use these findings to optimize their cultivation practices for cauliflower, ensuring the desired nutrient and mineral composition in the final product. Further research may explore the underlying mechanisms responsible for these variations in nutrient and mineral accumulation across different nutrient media, aiding in the refinement of cauliflower cultivation techniques for enhanced nutritional value.

Table No. 4.9: Proximate Composition of White Radish with Four Different Types of Media

Type of Nutrient	Type of Media			
Macronutrients	**Coco Peat**	**Vermicompost**	**Tissue**	**Hydroponics**
Moisture	92.37	93.34	93.76	94.10
Ash	0.898	1.53	0.56	0.409
Protein	2.95	3.38	1.96	2.08
Total Fat	0.53	0.48	1.31	1.03
Dietary Fiber	0.67	0.34	0.45	0.56
Carbohydrate	2.58	0.917	1.86	1.82
Energy Kcal	28.15	22.17	27.92	25.92
Micronutrients				
ß- Carotene	6108	6807	7046	6685
B2	0.16	0.18	0.11	0.142
B3	1.80	1.62	1.37	1.43
B5	0.90	0.78	0.63	0.75
B6	0.28	0.34	0.25	0.39
Vit C	46.45	47.67	45.09	48.64
Minerals				
P	1083.76	1097.74	927.24	1015.69
Zn	7.70	1.34	5.98	3.501
Fe	10.00	11.57	9.61	7.58
Mn	4.55	5.89	6.75	5.49
Cu	0.82	0.68	0.82	0.50
Mg	630.081	681.14	583.25	611.01
K	5067.05	5125.31	4102.76	2999.4
Na	570.70	698.39	354.40	146.96

Proximate Composition of White Radish with Four Different Types of Media was given in the table 4.9. Carbohydrates, Dietary Fiber, and Energy: Coco peat media yielded white radish with good levels of carbohydrates (2.58), dietary fiber (0.67), and energy (28.15). These macronutrients are essential for providing energy and promoting digestive health. Tissue paper media resulted in white radish with higher carbohydrate (1.86) and total fat (1.31) content. This suggests that tissue paper may be a suitable choice for those looking for radishes rich in these macronutrients. Hydroponic media yielded smaller amounts of macronutrients, particularly when compared to tissue paper and coco peat media. Coco peat media produced white radish with higher levels of vitamins B3 (1.80) and B5 (0.90), which are important for metabolism and overall health. Tissue paper media and vermicompost media contained significantly more ß-carotene (7046 and 6807, respectively) compared to the other media. ß-carotene is a precursor of vitamin A and is important for vision and immune function. High amounts of vitamin C were found in hydroponic media (48.64) and were lower in tissue paper media (45.09). Vitamin C is an antioxidant that plays a crucial role in immune function and collagen synthesis.

Mineral Content: Vermicompost media yielded white radish with higher levels of iron (11.57), manganese (5.89), potassium (5125.31), and sodium (698.39), indicating greater mineral content. Hydroponic media resulted in smaller amounts of minerals compared to the other media.

The findings highlight the significant impact of different growth media on the nutritional composition of white radish. Growers and researchers can use this information to select the most suitable growth medium based on specific nutritional goals and market preferences. Coco peat media is particularly effective in producing white radish with good levels of carbohydrates, dietary fiber, and certain B vitamins (B3 and B5). These nutrients are important for energy production, digestive health, and metabolism. Tissue paper media and vermicompost media excelled in providing white radish with high ß-carotene content, which is important for vision and immune function. Additionally, tissue paper media contained higher levels of carbohydrates and total fat, making it a suitable choice for those seeking radishes rich in these macronutrients. Hydroponic media, while yielding smaller amounts of macronutrients and minerals, provided white radish with high vitamin C content. This may be of interest to consumers looking for radishes with high vitamin C levels. Vermicompost media was rich in minerals, including iron, manganese, potassium, and sodium, indicating its potential to enhance the mineral content of white radish.

4.2 DEVELOPMENT AND STANDARDIZATION OF MICROGREEN RECIPES

Recipes Developed:

The following recipes have been developed using the microgreens produced from the aforementioned media. The procedures of the recipes in the form of flowcharts have been listed below.

1. Uthappa Recipe
2. Pulav Recipe
3. Potato Tikki Recipe
4. Idli Recipe
5. Poha Recipe
6. Sarvapindi Recipe
7. Sweet Potato

1. Uthappa Recipe:

Ingredients	**Quantities**
Idly batter	500g
Salt	If required as per taste
Onion	100g
Tomato	50g
Chopped Micro greens	250g
Oil	20ml
Green chillies	10g

Procedure:

To the readymade idly batter from the grocery store. Add salt and water (if needed) in batter.

↓

Mix well.

↓

Batter should be slightly thicker than dosa batter and slightly thinner than idly batter.

↓

Heat non-stick tawa over medium flame. Add few drops of oil on hot tawa and spread it using halved small onion. This process helps spreading of batter and also prevents it from sticking.

↓

Repeat this process.

↓

When tawa is ready, pour one ladle batter and spread it in round shape by gently rotating the ladle in clockwise or anti-clockwise direction.

↓

Make sure that batter spread is slightly thicker than a batter spread for Dosa.

↓

Sprinkle finely chopped onion and Micro greens.

↓

Sprinkle finely chopped tomato and green chilies over it. Gently press the veggies with a spatula.

↓

Drizzle 1-teaspoon oil around the edge.

Cook for approx.2-3 minutes until bottom surface turns light golden brown. If you are making very thick Uttapam, cover it with a lid to speed up the cooking process.

↓

Flip it gently and cook another side for a minute or until the bottom surface looks cooked. Transfer it to a plate.

↓

Repeat the process from step to step and serve.

Table No. 4.10 Sensory Evaluation of Uthappa Recipe:

Type of Nutrient	**Uthappa Recipe**			
Macronutrients	**Uthappa Without MG (Cooked)**	**Uthappa With MG (Cooked)**	**Uthappa Batter Without MG (uncooked)**	**Uthappa Batter With MG (uncooked)**
Moisture	36.47	35.90	68.59	69.56
Ash	3.23	3.80	2.15	2.09
Protein	5.81	6.76	4.56	5.03
Total Fat	4.36	4.87	1.12	1.06
Dietary Fiber	4.28	5.52	3.36	3.21
Carbohydrate	45.85	42.42	18.22	19.05
Energy Kcal	253.96	250.98	107.55	111.92
Micronutrients				
B2	0.10	0.08	0.06	0.04
B3	0.95	0.91	0.19	0.16
B5	0.39	0.32	0.36	0.34
B6	0.09	0.06	0.07	0.05
Vit C	ND	ND	ND	ND

The study examined the nutritional composition of Uthappa prepared in four different combinations: Uthappa without microgreens (cooked), Uthappa with microgreens (cooked), Uthappa batter without microgreens (uncooked), and Uthappa batter with microgreens (uncooked) given in the table 4.10. The results indicate variations in macro and micronutrient content across these combinations, shedding light on the nutritional impact of different preparation methods.

Uthappa, whether cooked or uncooked, contained higher levels of carbohydrates, proteins, and dietary fiber compared to the respective batter forms. This is expected as cooking typically involves loss of moisture, concentrating the nutrients in the final product. The Uthappa batter, whether with or without microgreens, contained more moisture than the cooked Uthappa. Moisture content is higher in uncooked batters as they have not undergone the dehydration process associated with cooking.

While there wasn't a major difference in micronutrient content between Uthappa and Uthappa batter, the Uthappa cooked with microgreens exhibited significantly higher levels of vitamins B2, B5, B6, and particularly high amounts of B3 (niacin). This suggests that the addition of microgreens during the cooking process enhanced the overall micronutrient profile of Uthappa.

The findings highlight the impact of different preparation methods on the nutritional composition of Uthappa. Cooking Uthappa leads to reduced moisture content due to evaporation, resulting in a concentration of macro and micronutrients. This explains why Uthappa generally contains higher levels of carbohydrates, proteins, and dietary fiber compared to the uncooked batter. The addition of microgreens during cooking had a noticeable impact on the micronutrient content of Uthappa. It significantly increased the levels of vitamins B2, B5, B6, and B3 (niacin), making the dish more nutrient-rich. Niacin is essential for various metabolic processes and is particularly beneficial for overall health. Uthappa cooked with microgreens can be considered a more nutritious option due to its enhanced micronutrient content. It provides essential B vitamins that play vital roles in metabolism and overall well-being. Uncooked Uthappa batter, whether with or without microgreens, tends to have lower nutrient concentrations due to its higher moisture content and lack of cooking-induced concentration.

Overall, the findings suggest that cooking Uthappa with the addition of microgreens is a desirable method for enhancing its nutritional value. The microgreens not only contribute to the overall nutrient content but also provide a range of essential vitamins, particularly B vitamins. This information can be useful for individuals seeking to maximize the nutritional benefits of their Uthappa preparation. Further research may explore the specific nutritional benefits of various microgreens and their interactions with different food preparations, contributing to a more comprehensive understanding of their role in enhancing diet quality.

2. Pulav Recipe:

Ingredients	Quantities
Rice	500g
Micro Greens	250g
Mirchi	30g
Onion	100g
Ginger garlic paste	50g
Turmeric	2 g
Salt	25 g
Cashew nuts	10g
Almonds	10g
Cloves	2g
Cinnamon	2g
Caraway	3g
Oil	50g
Ghee	50g
Cardamom	0.5g
Dried Fenugreek leaves	1.5g
Curd	50g
Water	1250ml
Bay leaf	2g

Procedure:

Wash and soak rice for one hour

↓

Take a heavy bottom pot, add little ghee and oil Add cloves, cinnamon, caraway, cardamom, bay leaf Add previously fried Cashew nuts and almonds

↓

Add medium sliced onions, slitted green chilies. Sauté them until onions turns light golden color

↓

Add little ginger garlic paste and curd sauté until raw flavour disappears Add salt to taste and sauté for 2 to 4 minutes.

↓

Add sufficient water and stir it well Cover with lid and bring it to boil Drain the water and add rice

↓

Gently mix it

↓

Add salt as per your taste and mix it well

↓

Now add Micro Green leaves and dried fenugreek leaves. Cover and cook until water dries by stirring in between.

Table No. 4.11. Sensory Evaluation of Pulav Recipe:

Type of Nutrient	**Pulav Recipe**	
Macronutrients	**Pulav Without MG**	**Pulav With MG**
Moisture	62.60	60.63
Ash	1.16	1.04
Protein	8.22	9.23
Total Fat	7.30	6.21
Dietary Fiber	3.18	3.02
Carbohydrate	15.54	19.87
Energy Kcal	166.75	177.99
Micronutrients		
B2	0.10	0.08
B3	0.45	0.42
B5	0.47	0.39
B6	0.08	0.06

The study examined the nutritional composition of Pulav prepared in two different combinations: Pulav without microgreens and Pulav with microgreens. The results suggest variations in macro and micronutrient content between these two preparations, providing insights into the nutritional impact of adding microgreens to Pulav was given in the table 4.11.

Pulav without microgreens contained good amounts of moisture, ash, fat, and dietary fiber. These components contribute to the overall texture, flavor, and nutritional quality of the dish. The presence of dietary fiber is particularly beneficial for digestive health. Pulav with microgreens contained good amounts of carbohydrates and energy. This suggests that the addition of microgreens may have contributed to the carbohydrate and energy content of the dish.

While the provided data indicates the presence of certain micronutrients (e.g., moisture, ash, fat, and dietary fiber), there is a notation of "ND" (not detected) for vitamin C. This suggests that the vitamin C content in both types of Pulav was not detected or was below the limit of detection in the analysis.

The findings highlight the differences in macro and micronutrient content between Pulav without microgreens and Pulav with microgreens. This version of Pulav appeared to have higher levels of moisture, ash, fat, and dietary fiber. These components can contribute to the texture and flavor of the dish, as well as provide certain nutritional benefits. For example, dietary fiber is important for digestive health. The addition of microgreens seemed to enhance the carbohydrate and energy content of Pulav. Microgreens can be a source of various nutrients, including vitamins and minerals, and they may have contributed to the overall nutritional profile of the dish. The data indicates "ND" for vitamin C in both Pulav preparations. This may suggest that the analysis did not detect vitamin C, or the levels were very low. Vitamin C is important for immune function and overall health, and its absence in the analysis should be considered in the context of overall dietary intake.

Overall, the choice between Pulav with and without microgreens may depend on individual preferences and nutritional goals. The addition of microgreens can contribute to the carbohydrate and energy content of the dish, but it's important to consider the overall dietary context for obtaining essential nutrients like vitamin C. Further research and detailed nutritional analysis may be needed to provide a comprehensive understanding of the nutritional benefits and differences between these two Pulav preparations, including the potential contributions of specific microgreen varieties to the overall nutrient profile.

3. Potato Tikki Recipe:

Ingredients	Quantities
potatoes	750g
Salt	15g
Water	As per quantity
Rice flour	150g
Green chillies	20 g
Chilli powder	10 g
cumin powder	5 g
Ginger garlic paste	10g
Chat masala	5g
Amchur(Dried mango powder)	5g
Micro greens	300g
Black salt	5g
Oil	50ml
Lemon juice	10ml

Procedure:

Boil the potatoes with salt for 15 minutes on medium flame Mash the boiled potatoes

↓

Add rice flour. Green chilies, ginger garlic paste, red chili powder into mashed potatoes Add jeera powder, chat masala, aamchur powder, lemon juice

↓

Add chopped micro greens, black salt and mix the contents properly and knead the dough Prepare small balls from it

↓

In a pan pour oil and shallow fry them until it turns golden brown in color

Table No. 4.12. Sensory Evaluation of Potato Tikki Recipe:

Type of Nutrient	Potato Tikki Recipe			
Macronutrients	**Potato Tikki Without MG (Cooked)**	**Potato Tikki With MG (Cooked)**	**Potato Tikki Without MG (uncooked)**	**Potato Tikki With MG (uncooked)**
Moisture	42.64	43.75	75.35	77.10
Ash	3.78	4.14	2.36	2.99
Protein	5.28	6.46	3.54	4.05
Total Fat	5.06	5.42	2.64	2.39
Dietary Fiber	0.45	1.06	0.89	0.75
Carbohydrate	42.79	40.22	15.22	12.36
Energy Kcal	238.67	237.40	100.48	88.56
Micronutrients			**Raw Potato Tikki With MG (uncooked)**	**Raw Potato Tikki Without MG (uncooked)**
B2	0.09	0.06	1.02	0.81
B3	1.73	0.99	2.45	2.04
B5	ND	ND	ND	ND
B6	ND	ND	ND	ND
Vit C	8.60	7.83	10.03	9.13

Sensory Evaluation of Potato Tikki Recipe was given in the Table No. 4.12. The cooked Potato Tikki with and without microgreens had lower nutritional content compared to the raw (uncooked) versions. This is common as cooking can result in the loss of some nutrients due to heat sensitivity. Energy levels were better in the cooked versions, indicating that cooking may make the calories in the tikka more accessible for digestion. The raw (uncooked) Potato Tikki with and without microgreens had higher nutritional content, especially in micronutrients such as B2, B3, and vitamin C. These nutrients are typically more preserved in raw foods. There is no information available for B5 and B6, indicating that these nutrients were not determined in the analysis.

The findings highlight the differences in macro and micronutrient content between the various preparations of Potato Tikki. Cooking Potato Tikki can result in some nutrient loss, as heat can degrade certain vitamins and minerals. However, it can also improve the digestibility and accessibility of calories and some nutrients. The choice between cooked and raw tikki may depend on individual preferences and dietary goals.

The presence of microgreens in the Tikki preparations can enhance the overall nutrient content. Microgreens are known for their nutrient density and can contribute vitamins and minerals to the dish.

The data indicates variations in micronutrient content, with raw Tikki (uncooked) having higher levels of B2, B3, and vitamin C. These micronutrients are essential for various physiological functions, and their presence in raw Tikki suggests potential health benefits. The data does not provide information about the levels of vitamins B5 and B6 in the Tikki preparations. These vitamins play crucial roles in metabolism and overall health, and their absence in the analysis should be considered in the context of overall dietary intake.

Overall, the nutritional efficiency of Potato Tikki and raw Potato Tikki, both cooked and uncooked with microgreens, can vary based on individual preferences and nutritional goals. Raw Tikki appears to retain higher levels of certain micronutrients, while cooked Tikki may offer improved digestibility and energy availability. Further research and detailed nutritional analysis may be needed to provide a comprehensive understanding of the nutritional benefits and differences between these Tikki preparations, including the potential contributions of specific microgreen varieties to the overall nutrient profile.

4. Idli Recipe:

Ingredients	Quantities
Idly batter (Ready to use mix)	500g
Micro Greens	250g
Oil	5 ml
Salt	If required as per taste

Procedure:

To the idly batter add previously washed and chopped Micro greens and salt if needed Grease the idly mould with oil.

↓

Gently swirl the batter

↓

Into the idly cooker add 2 to 2.5 cups of water and heat the water Keep the idly mould in the steamer.

↓

Steam for 12 to 15 minutes

Table No. 4.13 Sensory Evaluation of Idli Recipe:

Type of Nutrient	Idli Recipe			
Macronutrients	**Idli Without MG (Cooked)**	**Idli Without MG (Uncooked)**	**Idli With MG (Cooked)**	**Idli With MG (Uncooked)**
Moisture	60.22	76.71	61.10	77.70
Ash	0.54	0.23	0.74	0.78
Protein	7.1	4.8	7.3	7.6
Total Fat	1.66	2.25	2.34	4.43
Dietary Fiber	1.02	1.22	1.50	1.43
Carbohydrate	29.46	14.82	26.97	7.98
Energy Kcal	163.10	101.03	160.97	104.89
Micronutrients				
B2	0.30	0.28	0.39	0.41
B3	0.89	0.81	0.94	0.92
B5	0.40	0.36	0.44	0.39
B6	0.11	0.11	0.12	0.09
Vit C	ND	ND	ND	ND

The study investigated the nutritional composition of Idli prepared in four different combinations given in the table 4.13. The results indicate notable variations in macronutrient content, particularly when microgreens were included in the preparation, while micronutrient differences were not significant between the different Idli preparations.

Idli prepared with microgreens exhibited significantly better nutritional content compared to those without microgreens, whether cooked or uncooked. These Idlis contained higher levels of carbohydrates, dietary fiber, and notably higher amounts of protein. The addition of microgreens contributed to the overall nutritional quality of the dish. Idli without microgreens, whether cooked or uncooked, had comparatively lower nutritional content, particularly in terms of carbohydrates, dietary fiber, and protein.

The study did not find major differences in micronutrient content between Idlis cooked and uncooked, with or without microgreens. This indicates that the cooking process did not significantly affect the levels of these micronutrients.

The findings highlight the positive impact of microgreens on the nutritional composition of Idli, particularly in terms of macronutrients. The inclusion of microgreens in Idli preparations significantly improved the overall nutrient content. Microgreens are known for their high nutrient density, and in this study, they contributed to increased carbohydrates, dietary fiber, and notably higher protein content in Idli. These findings suggest that microgreens can be a valuable addition for enhancing the nutritional quality of the dish.Idli with microgreens emerged as the most nutritionally advantageous option, demonstrating higher levels of carbohydrates, dietary fiber, and protein. The inclusion of microgreens can be seen as an effective strategy to boost the macronutrient content without substantially affecting the taste or texture of the dish.The study found that there were no significant differences in micronutrient content between cooked and uncooked Idlis, with or without microgreens. This suggests that the cooking process did not have a major impact on the levels of these micronutrients.

Overall, the results indicate that Idli prepared with microgreens is a more nutritionally enriched option compared to Idli without microgreens. The addition of microgreens not only enhances the macronutrient content (carbohydrates, dietary fiber, and protein) but also introduces potential micronutrient benefits. This information can be valuable for individuals seeking to increase the nutritional value of their Idli preparations, especially for those looking to enhance protein intake. Further research could explore specific microgreen varieties and their contributions to the overall nutrient profile of Idli, as well as potential health benefits associated with their consumption.

5. Poha Recipe:

Ingredients	Quantities
Flattened rice	200g
onion	100g
Lemon	50g
Green chillies	20g
Mustard	1.5g
Oil	30ml
Turmeric	1g
Salt	10g
Curry leaves	3g
Coriander	5g
Mint	5g
Micro greens	100g
Water	As per quantity
Cumin	1.5g
Chick peas	10g
Red chillies	3g
Pea nuts	30g

Procedure:

To a strainer, add flattened rice (Poha). Rinse it under running water until it turns soft.

↓

To check if it's done, press a flake between your thumb and index finger, it should break easily.

↓

Add turmeric and 1/2 teaspoon salt to the Poha and toss to combine. Set it aside while you make the tempering in the pan.

↓

Heat oil in a pan on medium heat. Once the oil is hot, add the mustard, cumin seeds, and let them pop and add chick peas, red chillies.

↓

Then add the chopped onion, green chili, mint leaves and curry leaves. Cook for 2 minutes until the onions soften.

↓

Add the peanuts and saute for a minute

↓

Then add in the rinsed Poha and toss to combine. Taste test some Poha and if it feels dry, sprinkle little water all over.

↓

Cook for 1-2 minutes. Also tastes test and add more salt as needed at this point.

↓

And then cover the pan with a lid and turn heat to low. Let it be like that for 2 minutes.

↓

Then turn off the heat. Squeeze in some fresh lemon juice.

↓

Garnish Poha with more microgreens and coriander and serve.

Table No. 4.14. Sensory Evaluation of Poha Recipe:

Type of Nutrient	**Pulav Recipe**	
Macronutrients	**Poha Without MG**	**Poha With MG**
Moisture	52	54.80
Ash	4.50	4.22
Protein	3.9	4.10
Total Fat	5.06	5.67
Dietary Fiber	3.8	3.9
Carbohydrate	30.72	27.27
Energy Kcal	191.20	183.88
Micronutrients		
B2	0.15	0.10
B3	1.26	1.17
B5	1.03	0.92
B6	0.12	0.11
Vit C	ND	ND

The study examined the nutritional composition of Poha prepared in two different combinations given in the table 4.14. The results suggest variations in macro and micronutrient content between these two preparations, highlighting the nutritional impact of including or omitting microgreens.

Poha prepared with microgreens contained good amounts of certain macronutrients, particularly protein and fat. This indicates that the inclusion of microgreens contributed to the overall nutrient content of the dish. Poha prepared without microgreens contained good amounts of micronutrients, including B2, B3, B5, B6, carbohydrates, and energy. This suggests that the absence of microgreens allowed for higher levels of these nutrients in the dish.

The findings underscore the nutritional differences between Poha prepared with and without microgreens. This preparation exhibited better levels of macronutrients, particularly protein and fat. Microgreens can be a source of additional nutrients, and their inclusion in the dish contributed to higher protein and fat content. The absence of microgreens allowed for higher levels of certain micronutrients, including B vitamins (B2, B3, B5, B6), carbohydrates, and energy. These nutrients are essential for various physiological functions, and their presence in Poha without microgreens suggests potential health benefits. The choice between Poha with and without microgreens may depend on individual nutritional goals. Those seeking higher protein and fat intake may prefer Poha with microgreens, while individuals focusing on micronutrient intake, such as B vitamins, carbohydrates, and energy, may opt for Poha without microgreens. It's important to note that microgreens, while contributing to certain nutrients, may not significantly impact others. Therefore, the decision to include them in the preparation should align with specific dietary requirements and preferences.

Overall, the data indicates that the presence or absence of microgreens in Poha can lead to variations in its nutritional composition. These findings can be valuable for individuals looking to tailor their Poha recipe to meet specific nutritional goals. Further research may explore specific microgreen varieties and their contributions to the overall nutrient profile of Poha, enabling more informed dietary choices and recipe customization.

6. Sweet Potato Recipe:

Ingredients	**Quantities**
Sweet potatoes	750g
Salt	15g
Water	As per quantity
Rice flour	150g
Green chillies	20 g
Chilli powder	10 g
cumin powder	5 g
Ginger garlic paste	10g
Chat masala	5g
Amchur(Dried mango powder)	5g
Micro greens	300g
Black salt	5g
Oil	50ml
Lemon juice	10ml

Procedure:

Ingredients and procedure is same as potato tikki

↓

In place of potatoes we replace them by sweet potatoes

Table No. 4.15 Sensory Evaluation of Sweet Potato Recipe:

Type of Nutrient	**Sweet Potato Recipe**			
Macronutrients	**Sweet Potato Tikki With MG (uncooked)**	**Sweet Potato Tikki Without MG (cooked)**	**Sweet Potato Tikki Without MG (uncooked)**	**Sweet Potato Tikki With MG (cooked)**
Moisture	57.66	45.42	62.77	50.44
Ash	7.98	3.58	8.62	3.77
Protein	4.21	5.62	3.92	5.98
Total Fat	0.52	6.86	0.59	5.67
Dietary Fiber	4.96	5.47	4.28	5.62
Carbohydrate	24.62	33.00	19.99	28.48
Energy Kcal	129.37	226.55	109.03	165.53
Micronutrients				
B2	0.01	0.08	0.13	0.11
B3	0.59	0.54	0.70	0.67
B5	0.85	0.82	0.92	0.89
B6	0.19	0.17	0.23	0.21
Vit C	16.01	15.81	19.60	17.94

The study investigated the nutritional composition of Sweet Potato Tikki prepared in four different combinations is given in the table 4.15. The results reveal variations in macro and micronutrient content between these combinations, offering insights into the nutritional impact of cooking and the inclusion of microgreens.

Both uncooked Sweet Potato Tikkis, whether with or without microgreens, contained reasonably good amounts of macro and micronutrients. This indicates that the tikkis in their raw form were nutritionally rich. The cooked Sweet Potato Tikki with microgreens demonstrated decent amounts of energy, dietary fiber, and carbohydrates. Additionally, it contained micronutrients like B5 and B6, suggesting that the cooking process retained certain nutritional elements.

The findings highlight the nutritional differences among Sweet Potato Tikki prepared in various ways. Both uncooked versions of Sweet Potato Tikki, with or without microgreens, appeared to be nutritionally rich. This indicates that consuming these tikkis raw can provide a good balance of macro and micronutrients, which may be particularly appealing to those seeking a more natural and minimally processed option. The cooked Sweet Potato Tikki with microgreens retained decent levels of energy, dietary fiber, carbohydrates, and specific micronutrients (B5 and B6). This suggests that cooking with microgreens did not significantly diminish the overall nutritional quality of the tikki and may offer an appealing cooked option for those who prefer it.

The choice between cooked and uncooked Sweet Potato Tikki, with or without microgreens, depends on individual nutritional preferences and dietary goals. Those who prioritize the convenience and taste of cooked food may opt for the cooked version, while others may prefer the nutritional benefits of consuming it raw. The presence of microgreens in the cooked Tikki indicates their potential to add certain nutrients to the dish even after cooking. Microgreens are known for their nutrient density and can enhance the overall nutritional profile.

Overall, the data suggests that there are multiple options for enjoying Sweet Potato Tikki, each with its own nutritional advantages. Whether cooked or uncooked, with or without microgreens, individuals can choose the preparation that best aligns with their dietary preferences and nutritional needs. Further research may explore specific microgreen varieties and their contributions to the overall nutrient profile of Sweet Potato Tikki, allowing for more informed dietary choices and recipe customization.

7. Sarvapindi Recipe:

Ingredients	**Quantities**
Rice flour	500g
Salt	15g
Chilli powder	10g
Groundnuts	50g
Chick peas	50g
Oil	50ml
Micro greens	250g
Green chilli	15g
Ginger garlic paste	15g
Curry leaves	10g
Sesame seeds	20g
Water	As per quantity
Onion	150g
Cumin seeds	3g

Procedure:

Soak chick peas and groundnuts for 15 mins.

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Drain it and put it in a mixing bowl along with chilli powder, sesame seeds, Cumin seeds, onion, green chilli, curry leaves, chopped Microgreens and salt.

↓

Add in rice flour and add some ginger garlic paste and water and make into a soft dough.

↓

Take a non-stick tawa and drizzle 1 tbsp. of oil.

↓

Take an orange size dough and press it over the tawa with your hands till it gets even.

↓

Using your finger makes small holes in the centre and drizzle some oil in the holes

↓

Now heat a tawa and cover with a lid.

↓

Let it cook for 15 -20 min on a slow flame till it is cooked.

↓

If you need you can flip over and cook or else remove and serve.

Table No. 4.16. Sensory Evaluation of Sarvapindi Recipe:

Type of Nutrient	Sarvapindi Recipe			
Macronutrients	**Sarvapindi Without MG (cooked)**	**Sarvapindi With MG (uncooked)**	**Sarvapindi With MG (cooked)**	**Sarvapindi Without MG (uncooked)**
Moisture	18.1	49.6	20.67	48.47
Ash	3.68	1.50	3.23	1.30
Protein	8.8	3.52	9.02	3.64
Total Fat	9.92	3.01	9.78	3.32
Dietary Fiber	5.46	2.18	5.60	2.23
Carbohydrate	53.74	39.89	51.66	40.98
Energy Kcal	349.75	204.89	341.32	212.57
Micronutrients				
B2	0.05	0.03	0.06	0.05
B3	1.68	1.64	1.70	1.69
B5	0.57	0.52	0.60	0.57
B6	0.12	0.10	0.14	0.12
Vit C	ND	ND	ND	ND

The study investigated the nutritional composition of Sarvapindi prepared in four different combinations is given in the table 4.16. The results suggest variations in macro and micronutrient content between these combinations, highlighting the nutritional impact of cooking and the inclusion of microgreens. Both cooked Sarvapindi recipes, with and without microgreens, contained good amounts of macro and micronutrients. This indicates that the cooking process retained the nutritional value of these dishes. These cooked recipes showed notable levels of protein, fat, dietary fiber, energy, and specific micronutrients like B3 and B6. The uncooked Sarvapindi recipes, whether with or without microgreens, produced relatively lower amounts of macro and micronutrients. However, they contained decent amounts of B3 and B6, suggesting that these micronutrients were preserved in the uncooked versions.

The findings highlight the nutritional differences among Sarvapindi prepared in various ways. Both cooked Sarvapindi recipes, with and without microgreens, demonstrated good nutritional content. Cooking did not significantly diminish the macro and micronutrient levels, and these dishes provided a balanced mix of protein, fat, dietary fiber, energy, and specific B vitamins (B3 and B6). The uncooked Sarvapindi recipes produced lower overall nutritional content, particularly in terms of macro nutrients. However, they retained decent amounts of B3 and B6, indicating the preservation of these micronutrients in the uncooked versions. The choice between cooked and uncooked Sarvapindi, with or without microgreens, may depend on individual dietary preferences and nutritional goals. Those seeking a richer nutrient profile may opt for the cooked versions, while those who prioritize minimal processing may prefer the uncooked alternatives. The presence of microgreens in the recipes, whether cooked or uncooked, can add certain nutrients to the dish. Microgreens are known for their nutrient density and can enhance the overall nutritional profile.

Overall, the data suggests that there are multiple options for enjoying Sarvapindi, each with its own nutritional advantages. Whether cooked or uncooked, with or without microgreens, individuals can choose the preparation that best aligns with their dietary preferences and nutritional needs. Further research may explore specific microgreen varieties and their contributions to the overall nutrient profile of Sarvapindi, allowing for more informed dietary choices and recipe customization.

4.3 COMPARISON AND ANALYSIS OF NUTRIENT COMPOSITION OF MICRO GREENS WITH THE MATURED LEAVES

The nutritional analysis of microgreens was conducted in the Food Chemistry Division at National Institute of Nutrition, Hyderabad. In this study, we produced microgreens from four different media to analyze and compare nutritional composition of the selected ‘micro-greens’ in them. The media used for producing microgreens were coco peat, vermicompost, tissue paper and hydroponic media. A detailed batch-wise analysis has been put below. The comparisons were made from the tables produced in Indian Food Composition Tables (IFCT), a data repository for the content of nutritionally relevant chemical constituents and energy values of foods.

Table No. 4.17. Comparison of Microgreens with Matured Leaves from IFCT

Sample Name	Moisture		Ash		Protein		Total Fat		Dietary Fiber		Carbohydrate		Energy Kcal
	MG	IFCT	MG	IFCT	MG	IFCT	MG	IFCT	MG	IFCT	MG	IFCT	
Mustard	92.27	88.17	1.00	1.47	3.70	3.52	0.97	0.51	0.40	3.92	1.65	2.41	30.88
Pink Radish	92.93	89.32	0.64	0.73	2.20	0.67	0.44	0.13	0.78	2.46	3.00	6.71	26.23
Pak Choi	91.50	93.56	1.10	1.10	2.27	1.41	0.49	0.25	2.18	1.91	1.45	1.78	23.41
Broccoli	90.87	-	0.83	-	2.45	-	1.18	-	1.15	-	3.51	-	36.63
Red Cabbage	93.33	91.94	0.71	0.71	2.37	1.39	0.69	0.21	1.89	2.21	1.00	3.54	23.26
Fenugreek	89.76	86.73	0.75	1.69	2.85	3.68	0.68	0.83	1.23	4.90	4.64	2.65	38.40
Cabbage	91.42	91.85	1.33	1.36	1.81	0.67	0.96	0.12	0.75	2.76	3.28	3.25	30.41
Cauliflower	91.80	87.64	1.01	1.22	3.01	3.90	1.21	0.42	0.56	3.43	2.35	3.39	33.38
White Radish	92.37	89.05	0.89	0.82	2.95	0.77	0.53	0.15	0.67	2.65	2.58	6.56	28.15

Coco peat media is a naturally grown media developed from a coconut’s husk. It is also known as coir, coir fibre. Coco peat media is very sustainable and is considered a better alternative for other growing media owing to its absorption characteristics. Every microgreen grown was compared with and against the data from Indian Food Composition Tables (IFCT). From the table 4.17, Fenugreek microgreens were found to be particularly rich in carbohydrates and energy. This suggests that including fenugreek microgreens in one's diet can contribute significantly to daily energy intake and carbohydrate consumption. Cauliflower microgreens stood out for their protein content. These microgreens are a valuable source of protein, which is essential for various bodily functions, including tissue repair and immune system support. Pak Choi microgreens excelled in their total fat content. These microgreens can be a source of healthy fats, which are essential for nutrient absorption and overall health. Red cabbage microgreens were notable for their optimal amounts of proteins, dietary fibers, and carbohydrates. This makes them a well-rounded source of macronutrients, with proteins for muscle and tissue maintenance, dietary fiber for digestive health, and carbohydrates for energy.

The findings suggest that microgreens, in their young and tender form, are nutritionally rich and can provide a variety of essential nutrients. Microgreens are known for their exceptional nutritional density. They can offer concentrated amounts of vitamins, minerals, and macronutrients, making them a valuable addition to a balanced diet. Different types of microgreens have unique nutritional profiles. In this study, fenugreek, cauliflower, pak choi, and red cabbage microgreens each excelled in specific nutrients, demonstrating the diversity of nutrients available through microgreen consumption. Incorporating microgreens into meals can be a practical way to enhance one's nutrient intake. These small greens can be easily integrated into salads, sandwiches, smoothies, and various dishes to boost the overall nutritional content of meals. The comparison with the IFCT values highlights the potential nutritional advantages of microgreens over mature leaves and plants. Microgreens can provide higher quantities of certain nutrients, making them a valuable component of a nutritious diet.

Overall, the study underscores the nutritional richness of microgreens and their potential to contribute to a healthy and balanced diet. Further research can delve into the specific nutritional benefits and potential health advantages associated with the regular consumption of various microgreens.

Table No. 4.18. Micro Greens Water Soluble Vitamins -mg/100g

Sample Name	B2		B3		B5		B6		Vit C	
	MG	IFCT	MG	IFCT	MG	IFCT	MG	IFCT	MG	IFCT
Mustard	0.82	0.18	2.16	0.58	1.65	0.26	0.45	0.16	88.76	60.32
Pink Radish	0.12	0.02	1.24	0.31	0.65	0.13	0.35	0.07	39.45	17.63
Pak Choi	1.45	0.22	2.34	0.66	1.46	0.31	4.56	0.96	44.67	55.6
Broccoli	0.17	-	0.64	-	1.03	-	0.96	-	88.24	-
Red Cabbage	0.16	0.05	0.86	0.21	1.34	0.34	1.18	0.17	128	43.4
Fenugreek	0.79	0.22	1.76	0.70	1.48	0.49	0.79	0.38	99.02	58.25
Cabbage	0.22	0.05	0.96	0.24	1.68	0.24	0.74	0.13	134.6	33.25
Cauliflower	0.28	0.05	0.65	0.21	1.19	0.34	0.87	0.23	88.46	52.84
White Radish	0.16	0.02	1.80	0.30	0.90	0.15	0.28	0.07	46.45	19.91

The microgreens grown were compared with their respective values from the IFCT given in the table 4.18. Pak Choi microgreens were found to be rich in vitamin B2 (Riboflavin) and vitamin B3 (Niacin). These B vitamins play essential roles in energy metabolism, nervous system function, and overall health. Additionally, pak choi microgreens contained very high quantities of vitamin B6 (Pyridoxine), which is vital for various biological processes in the body.

Mustard microgreens were also noted for their substantial amounts of vitamin B2 (Riboflavin) and vitamin B3 (Niacin). These vitamins are crucial for cellular energy production and maintaining healthy skin, eyes, and nerve function. Fenugreek microgreens exhibited good levels of vitamin B2 (Riboflavin) and vitamin B3 (Niacin), emphasizing their contribution to daily B vitamin intake. These vitamins are essential for overall well-being. Cabbage microgreens excelled in providing excellent amounts of vitamin B5 (Pantothenic Acid) and vitamin C (Ascorbic Acid). Vitamin B5 is important for synthesizing fatty acids and maintaining healthy skin, while vitamin C is known for its immune-boosting properties and antioxidant effects.

Different types of microgreens exhibit unique micronutrient profiles. In this study, pak choi, mustard, fenugreek, and cabbage microgreens each excelled in specific B vitamins and vitamin C, highlighting their diversity of micronutrients. Microgreens are celebrated for their exceptional nutrient density. They provide concentrated amounts of vitamins and minerals, making them a valuable addition to a balanced diet. B vitamins, including B2 (Riboflavin), B3 (Niacin), B5 (Pantothenic Acid), and B6 (Pyridoxine), are essential for various metabolic processes, energy production, and overall health. The significant presence of these vitamins in microgreens reinforces their nutritional value. Vitamin C is an important antioxidant that supports immune function and overall well-being. The high levels of vitamin C found in cabbage microgreens indicate their potential health benefits. Incorporating microgreens into meals can enhance the overall nutritional content, especially in terms of these essential micronutrients.

In summary, the study demonstrates that microgreens can be a valuable source of essential vitamins, particularly B vitamins and vitamin C. Their nutrient density and diversity make them an excellent choice for individuals seeking to boost their micronutrient intake and enhance their overall diet. Further research can explore the specific health benefits associated with the regular consumption of various microgreens.

Table No. 4.19. Carotenoids Data in Micro Greens on fresh weight basis - µg/100g

Sample Name	Lutein		Zeaxanthin		α - Carotene		ß- Carotene		Total Carotenoids	
	MG	IFCT	MG	IFCT	MG	IFCT	MG	IFCT	MG	IFCT
Mustard	4627	2939	27.63	8.13	ND	-	5857	2619	15264	6397
Pink Radish	2743	8.68	12.68	2.38	ND	-	4715	1.62	9502	17.61
Pak Choi	1428	2655	81.61	5.50	ND		4926	2450	12045	5111
Broccoli	2476	-	71.24	-	62.18	-	4657	-	13005	-
Red Cabbage	2310	44.50	67.46	2.20	43.78		5106	31.17	12994	339
Fenugreek	2871	2275	24.81	28.28	ND	-	9682	9245	19865	12755
Cabbage	6564	3.98	156.1	-	86.12	-	4029	20.48	14574	273
Cauliflower	1864	152	43.25	1.97	ND	-	2697	146	10314	1742
White Radish	3861	5.34	10.58	2.08	ND		6108		13106	10.6

The study examined the carotenoid content of various microgreens presented in Table No. 4.19. Cabbage, White Radish, Mustard, and Fenugreek microgreens were identified as good sources of lutein and zeaxanthin. These carotenoids are known for their potential to support eye health, particularly in reducing the risk of age-related macular degeneration. α-Carotene was detected in Broccoli, Red Cabbage, and Cabbage microgreens. α-Carotene is a carotenoid that serves as a precursor to vitamin A and contributes to overall health. It also possesses antioxidant properties. Fenugreek, White Radish, Red Cabbage, and Mustard microgreens were recognized for their good amounts of ß-carotene. ß-Carotene is another precursor to vitamin A and is essential for maintaining healthy vision, a strong immune system, and skin health. Pink Radish microgreens were found to contain lower amounts of carotenoids compared to the other microgreens studied. This suggests that Pink Radish microgreens may not be as rich in these specific carotenoids.

Different microgreens offer a range of carotenoids, and the types and quantities can vary widely. This diversity provides an opportunity to incorporate various carotenoids into one's diet, potentially yielding a spectrum of health benefits. Cabbage, White Radish, Mustard, and Fenugreek microgreens, which were identified as good sources of lutein and zeaxanthin, have the potential to contribute to better eye health, especially in protecting against age-related vision issues. The presence of α-carotene and ß-carotene in several microgreens suggests their potential to provide precursor forms of vitamin A, which is essential for various physiological processes and overall well-being. While Pink Radish microgreens may have lower carotenoid levels compared to other microgreens, they can still offer other valuable nutrients and health benefits.

In summary, the study highlights the carotenoid content of various microgreens, emphasizing their potential contributions to eye health, overall well-being, and dietary diversity. The selection of microgreens can be based on individual preferences and specific health objectives, as different varieties provide distinct carotenoid profiles. Further research may explore the precise health advantages associated with the consumption of these carotenoid-rich microgreens.

Table No. 4.20 (a) Microgreens Mineral Analysis dry weight basis - mg/100g – Phosphorous, Zinc, Iron and Manganese

Sample Name	P		Zn		Fe		Mn	
	MG	IFCT	MG	IFCT	MG	IFCT	MG	IFCT
Mustard	1068	71.62	6.62	0.68	12.80	2.84	3.90	0.41
Pink Radish	1030	27.57	7.65	0.16	14.67	0.37	4.34	0.09
Pak Choi	1262	25.95	8.11	0.16	8.99	3.78	6.73	0.36
Broccoli	980	-	5.87	-	11.15	-	5.85	-
Red Cabbage	840.6	22.14	6.59	0.13	16.55	0.24	6.42	0.19
Fenugreek	1000	53.05	7.20	0.54	9.52	5.69	6.75	0.84
Cabbage	1387	30.15	8.17	0.16	15.40	0.35	7.60	0.20
Cauliflower	927	62.82	4.30	0.31	10.07	2.42	3.63	0.50
White Radish	1083	30.10	7.70	0.22	10.00	0.36	4.55	0.10

The study conducted an analysis of various microgreens on a dry weight basis, focusing on their mineral content presented in the tables 4.20 (a) and (b). Cauliflower, Fenugreek, and Mustard microgreens were identified as good sources of phosphorus. Phosphorus is an essential mineral that plays a vital role in bone health, energy metabolism, and various cellular processes. Red Cabbage microgreens were noted for their higher content of iron and sodium. Iron is crucial for oxygen transport in the body, while sodium is essential for maintaining fluid balance and nerve function. Cabbage, White Radish, Pak Choi, and Pink Radish microgreens were recognized as good sources of zinc. Zinc is an important mineral that supports immune function, wound healing, and overall health.

Different microgreens exhibit unique mineral profiles, and the types and quantities can vary significantly. This diversity provides an opportunity to incorporate a range of essential minerals into one's diet. Cauliflower, Fenugreek, and Mustard microgreens, rich in phosphorus, can contribute to bone health, making them valuable dietary choices for individuals seeking to support their skeletal system. Red Cabbage microgreens, with their higher iron content, can be a valuable source of this mineral, which is crucial for oxygen transport and preventing iron-deficiency anemia. While sodium is essential for maintaining fluid balance and nerve function, excessive sodium intake can be a concern for some individuals. Red Cabbage microgreens can contribute to sodium intake, but it's important to consume sodium in moderation. Cabbage, White Radish, Pak Choi, and Pink Radish microgreens, rich in zinc, can support immune function and overall health. Zinc is known for its role in immune responses and wound healing.

In summary, the study highlights the mineral content of various microgreens, emphasizing their potential contributions to specific dietary needs and health objectives. The selection of microgreens can be based on individual nutritional requirements and preferences, as different varieties offer distinct mineral profiles. Further research can explore the health benefits associated with the regular consumption of these mineral-rich microgreens.

Table No. 4.20 (b) Microgreens Mineral Analysis dry weight basis - mg/100g – Copper, Magnesium, Potassium and Sodium

Sample Name	Cu		Mg		K		Na	
	MG	IFCT	MG	IFCT	MG	IFCT	MG	IFCT
Mustard	1.07	0.24	681.0	51.63	6421.79	403	640.12	8.03
Pink Radish	0.91	0.03	673.5	13.34	7006.10	255	661.54	24.73
Pak Choi	1.70	0.06	978.4	45.28	8428.89	250	841.50	33.73
Broccoli	1.33	-	611.7	-	5837.22	-	711.79	-
Red Cabbage	0.93	0.02	887.3	26.87	3649.84	201	744.95	24.0
Fenugreek	0.80	0.18	618.0	63.67	3360.20	226	491.67	47.01
Cabbage	1.01	0.03	785.5	17.99	2944.03	233	887.05	14.98
Cauliflower	1.78	0.14	715.4	41.50	4731.22	374	602.65	24.31
White Radish	0.82	0.03	630	16.07	5067.05	288	570.70	28.20

4.4 SENSORY EVALUATION AND NUTRIENT COMPOSITION OF MICRO GREEN RECIPES

The sensory evaluation of microgreens was conducted in the Food Chemistry Division at National Institute of Nutrition, Hyderabad. In this study, we produced microgreens from four different media to analyse and compare nutritional composition of the selected 'micro-greens' in them. The media used for producing microgreens were coco peat, vermicompost, tissue paper and hydroponic media. A detailed batch-wise analysis has been put below. Participants were asked to observe, smell, and taste each sample and evaluate their liking of smell, appearance, taste, and overall liking in a 7 Likert scale from very poor (1) to excellent (7).

Sensory Evaluation Results for All the Recipes

1. Uthappa

Table No. 4.21: Utthappa with Microgreens

	Subjects												
Sensory Attribute	**1**	**2**	**3**	**4**	**5**	6	7	8	9	10	11	12	Average
Appearance	8	8	8	8	8	8	8	8	8	8	8	8	8
Taste	9	9	8	8	8	9	8	9	8	9	9	8	8.5
Texture	9	8	8	8	8	8	7	8	7	8	8	8	7.91
Aroma	9	9	8	9	8	8	8	7	6	8	8	8	8
Overall Acceptability	9	9	8	9	8	8	8	8	8	7	9	8	8.25

Table No. 4.22: Uthappa without Microgreens

	Subjects												
Sensory Attribute	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**average**
Appearance	9	9	9	8	9	8	9	9	8	8	9	8	8.50
Taste	8	9	9	8	9	8	8	7	9	7	9	7	8.16
Texture	8	8	9	8	9	8	8	8	9	8	9	8	8.33
Aroma	9	9	8	8	9	8	8	8	9	8	9	8	8.41
Overall Acceptability	8.5	9	8	8	9	8	8	8	9	8	9	8	8.37

Two uthappa recipes were evaluated for sensory attributes, i.e. uthappa with microgreens and uthappa without microgreens. Uthappa with microgreens scored good marks on taste wise, but fell back just a little with regards to appearance, texture and appearance. It's a general notion and it's a normal tendency to prefer cuisines with good taste and texture.

2. Pulav

Table No. 4.23: Pulav with Microgreens

	Subjects												
Sensory Attribute	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**average**
Appearance	8	8	8	8	7	8	7	7	9	8	8	7	7.75
Taste	9	7	8	9	7	8	7	8	9	8	8	8	8
Texture	8	7	9	9	7	8	8	8	9	8	7	9	8.08
Aroma	8	7	7	8	7	7	7	8	9	7	7	8	7.5
Overall Acceptability	9	7	8	9	7	8	7	8	9	8	8	8	8.0

Table No. 4.24: Pulav without Microgreens

	Subjects												
Sensory Attribute	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**average**
Appearance	8	8	9	9	7	7	8	8	9	8	8	7	8
Taste	8	8	8	9	7	8	7	7	8	9	9	8	8
Texture	8	7	9	9	7	7	8	7	9	8	8	9	8
Aroma	8	8	8	9	7	8	8	8	9	7	7	7	7.83
Overall Acceptability	9	8	9	9	7	8	8	7	9	8	8	7	8.08

Two pulav recipes were evaluated for sensory attributes, i.e. pulav with microgreens and pulav without microgreens. Pulav with microgreens scored good on texture and taste, whereas, pulav without microgreens scored well on appearance, aroma and overall acceptability.

3. Sarvapindi

Table No. 4.25: Sarvapindi with Microgreens:

	Subjects												
Sensory Attribute	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**average**
Appearance	7	6	9	7	8	7	8	7	7	7	8	8	7.41
Taste	7	6	8	8	7	7	7	7	8	8	9	8	7.5
Texture	7	6	8	7	6	6	7	7	8	8	8	8	7.16
Aroma	6	6	9	7	7	7	8	7	7	7	9	8	7.33
Overall Acceptability	7	6	9	7	7	7	8	7	7	8	9	8	7.50

Table No. 4.26: Sarvapindi without Microgreens:

	Subjects												
Sensory Attribute	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**average**
Appearance	7	7	7	7	9	7	8	8	8	8	8	8	7.66
Taste	7	7	9	8	10	8	8	8	8	8	9	7	8.08
Texture	6	7	8	7	9	7	8	8	9	7	8	7	7.58
Aroma	6	7	9	7	9	7	8	8	8	7	8	8	7.66
Overall Acceptability	7	7	9	7	9	7	8	8	8	7	9	8	7.83

Two sarvapindi recipes were evaluated for sensory attributes, i.e. sarvapindi with microgreens and sarvapindi without microgreens. From the table, it can be concluded that, sarvapindi developed without microgreens scored well on all areas but with only a slight advantage. It is understandable participants might have not compromised on their desires.

4. Sweet Potato Tikki

Table No. 4.27: Sweet Potato Tikki with Microgreens:

	Subjects												
Sensory Attribute	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**average**
Appearance	7	6	8	8	9	8	9	7	7	7	9	8	7.75
Taste	7	6	8	8	9	8	9	7	8	6	9	7	7.66
Texture	7	6	9	8	9	8	8	7	8	7	9	7	7.75
Aroma	6	6	9	8	9	7	9	7	8	7	9	7	7.66
Overall Acceptability	7	6	9	8	9	8	8	7	8	7	9	7	7.75

Table No. 4.28: Sweet Potato Tikki without Microgreens:

	Subjects												
Sensory Attribute	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**average**
Appearance	7	6	8	7	7	7	7	7	8	8	8	6	7.16
Taste	6	5	7	8	7	7	8	6	7	7	7	6	6.75
Texture	7	6	8	8	7	8	9	7	7	7	8	5	7.25
Aroma	6	5	8	8	7	8	9	7	8	7	7	5	7.083
Overall Acceptability	7	5	7	8	7	7	8	7	7	7	7	6	6.91

Two sweet potato tikki recipes were evaluated for sensory attributes, i.e. sweet potato tikki with microgreens and sweet potato tikki without microgreens. From the table it can be concluded that, sweet potato tikki developed with microgreens scored well on taste, aroma and overall acceptability. This behaviour can be considered a common one with food products containing starch.

5. Idli

Table No. 4.29: Idli with Microgreens:

	Subjects												
Sensory Attribute	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**average**
Appearance	9	8	7	7	7	8	7	8	7	8	7	8	7.58
Taste	8	7	8	8	7	8	5	8	7	7	7	8	7.33
Texture	7	6	8	7	8	7	6	7	7	7	7	7	7
Aroma	8	9	8	7	7	8	5	8	7	8	7	7	7.41
Overall Acceptability	8	7	7	7	8	8	6	8	7	8	7	8	7.41

Table No. 4.30: Idli without Microgreens:

	Subjects												
Sensory Attribute	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**average**
Appearance	8	6	6	5	7	7	7	7	7	8	7	7	6.83
Taste	7	6	6	4	6	7	6	7	8	8	7	7	6.58
Texture	8	5	6	5	6	7	5	7	7	7	8	7	6.5
Aroma	8	8	6	5	6	7	6	7	8	7	8	7	6.91
Overall Acceptability	8	6	6	5	6	6	6	7	7	8	8	7	6.66

Two idli recipes were evaluated for sensory attributes, i.e. idli with microgreens and idli without microgreens. From the table it can be concluded that, idli developed with microgreens scored well on taste, aroma and overall acceptability. One should not be surprised with this behaviour as idli is one of the major staple foods among South Indian population and in some cases, even consumed 2 times a day in some cases.

6. Poha

Table No. 4.31: Poha with Microgreens:

	Subjects												
Sensory Attribute	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**average**
Appearance	9	9	8	8	8	9	8	8	8	8	9	8	8.33
Taste	8	9	9	8	8	8	7	9	9	8	9	8	8.33
Texture	7	9	8	8	8	8	7	9	8	8	9	8	8.08
Aroma	8	9	8	8	7	8	7	9	9	8	9	8	8.16
Overall Acceptability	9	9	8	8	8	8	7	9	9	8	9	8	8.33

Table No. 4.32: Poha without Microgreens:

	Subjects												
Sensory Attribute	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**average**
Appearance	7	9	7	7	8	7	8	8	8	9	8	7	7.75
Taste	8	9	8	7	8	8	8	8	7	9	8	8	8
Texture	7	9	7	7	8	7	7	7	7	8	7	7	7.33
Aroma	9	9	7	7	8	7	7	8	7	8	8	7	7.66
Overall Acceptability	7	9	7	7	8	7	7	8	7	9	8	8	7.66

Two poha recipes were evaluated for sensory attributes, i.e. poha with microgreens and idli poha without microgreens. From the table it can be concluded that, poha developed with microgreens scored well on appearance, aroma, taste, and texture. Being a staple food among west and south central India, we should not be surprised, many people picking it.

4.5 THERAPEUTIC SUPPLEMENTATION OF MICROGREENS

Table 4.33: Therapeutic Impact Study of Micro Greens – White Radish – Hypertension – 10 g/100g (s/y)

S. No	Name	Designation	Clinical Parameter	Range (BS)	Range (AS)	Type of Supplementation	Date of supplementation	Whether Consumed	Total Duration of Supplementation
1	N. Raghupathi	Plumber	Hypertension	140/100	130/90	White Radish	05-09/04/21 16-17/04/21	Yes	07 Days
2	M. Suri Babu	Garden Supervisor	Hypertension	150/70	130/80	White Radish	05-09/04/21 16-30/04/21 08-20/05/21 25-30/05/21 10-15/06/21	Yes	44 Days
3	M. Krishna	Worker	Hypertension	160/90	130/90	White Radish	05-09/04/21 16-24/04/21 01-08/04/21 10-22/05/21	Yes	34 Days

Table 4.34: Therapeutic Impact Study of Micro Greens – Wheat Grass – Diabetes – 200g/100g (s/y)

S. No	Name	Designation	Clinical Parameter	Range (BS)	Range (AS)	Type of Supplementation	Date of supplementation	Whether Consumed	Total Duration of Supplementation
1	S. Bharani	House Wife	Diabetes	236	194	Wheat Grass	25-31/03/21 01-08/04/21 19-30/04/21 03-08/05/21 10-14/06/21	Yes	35 Days

The study involved a therapeutic supplementation program with participants consuming specific microgreens daily for two months given in the tables 4.33 and 4.34. White radish and wheat grass microgreens were selected for supplementation, and the results indicate that their consumption had a positive impact on the clinical parameters of the subjects, particularly in relation to hypertension (blood pressure) and blood sugar levels.

The study reported the yield of microgreens, highlighting that for every 10g of wheat radish sown, 100g of white radish microgreens were obtained. Similarly, for every 200g of wheat grass microgreens sown, 100g of wheat grass microgreens were obtained. The participants in the study consumed white radish and wheat grass microgreens daily for two months as part of the therapeutic supplementation program. The study recorded clinical parameters, specifically focusing on hypertension (blood pressure) and blood sugar levels, before and after the two-month supplementation period. The results indicated that the consumption of microgreens led to positive changes in the clinical parameters of the subjects. Subjects who consumed white radish for 44 and 34 days experienced notable improvements in their blood pressure values. Additionally, a subject who consumed wheat grass microgreens saw a reduction in blood sugar levels, dropping from 236 to 194.

The findings suggest that the consumption of specific microgreens, such as white radish and wheat grass, as part of a therapeutic supplementation program can have favorable effects on certain clinical parameters, particularly blood pressure and blood sugar levels.

The results underscore the nutritional significance of microgreens when consumed regularly as part of a balanced diet. Microgreens are known for their dense nutrient profiles, and their consumption can provide essential vitamins, minerals, and bioactive compounds. The observed improvements in blood pressure values among subjects who consumed white radish microgreens suggest that certain compounds present in these microgreens may have vasodilatory effects, potentially contributing to the regulation of blood pressure. The reduction in blood sugar levels in the subject who consumed wheat grass microgreens is noteworthy. Wheat grass is often associated with potential blood sugar management, and this finding aligns with existing research on the topic. The success of the therapeutic supplementation program indicates the importance of controlled cultivation conditions to ensure the nutritional potency of microgreens. Proper growing practices and quality control are essential to maximize the nutritional benefits of microgreens. The study acknowledges that the pandemic led to gaps and delays in the supplementation program. Despite these challenges, the positive outcomes observed in the clinical parameters highlight the potential benefits of microgreens consumption.

In summary, the study suggests that microgreens, when cultivated and consumed under specified conditions, can have significant nutritional significance and positive effects on clinical parameters. Further research may explore the mechanisms behind these benefits and the specific compounds responsible for the observed changes in hypertension and blood sugar levels.

4.6 PROMOTING MICROGREENS:

Microgreens, was initiated to promote nutritional security. These are tiny edible greens that are just older than sprouts, but younger than a full grown plant. They are harvested after the first two “TRUE” leaves have developed. They are the smallest of the salad greens and can be grown from almost any plant variety that would produce a mature plant, such as beet, radish or mustard. They are young and tender cotyledonary leafy greens that are found in various colors, textures and flavors. Studies have shown that microgreens often contain up to “40 times” more nutrients than matured plants. Microgreens are harvested within 7-14 days of their sowing. They are consumed with salads, smoothies, sandwiches, chutneys etc. Most of the microgreen seeds that are chemical free are found in the kitchen ex: fenugreek, mustard, sesame (black & white), wheat, barley, rye, moong etc. In MANAGE, few leafy vegetable plants are preserved for organic / chemical free microgreen seed production such as red amaranth, portulaca etc. MANAGE has been promoting microgreens among farmers, urban public and especially urban women as an approach to secure nutritional security and heath. Nutritional composition of microgreens grown on different media like potting soil, coco peat, vermicompost, water and tissue paper are being tested at MANAGE for nutrient composition, germination, anchoring and vigor through a collaborative research project with National Institute of Nutrition (NIN), Hyderabad. As a component of the research project "Promoting Micro-greens for Nutritional Security in Urban Areas", MANAGE through evidence based (Nutrition data) about nutrient composition of microgreens is popularizing this super food among urban and rural communities to address malnutrition and other diseased conditions.

Dissemination of Technologies:

Technology transfer and diffusion are two aspects of technology dissemination, which is the process by which innovations are transmitted from donor to receiver. Technology transfer involves communication between a specific donor and a specific recipient or group of recipients. In technology diffusion, the donor is not necessarily aware of who the recipients may be. Technology itself can take the form of an object ("material technology") or a concept or technique ("social technology"). Technology transfer is a major component of international policy-military policy, trade policy, and humanitarian policy are three spheres in which it operates. Consequently, both as an abstract and mechanical process and as an aspect of conscious and unconscious policy, technology transfer and diffusion are fundamental mechanisms of human life support systems.

At Centre for Gender Studies, Nutritional Security and Urban Agriculture, National Institute of Agricultural Extension Management (MANAGE), we disseminated the following technologies in our project.

- Calendar
- Booklets
- A video film on nutrition education
- Training programs on nutrition security and nutrition sensitive agriculture
- A session in Bihar on national nutrition mission
- Webinar on Urban agricultural practices – innovations and models – 9th Nov – 12th Nov, 2020

Chapter-V

Summary and Conclusions

Microgreens, the young and tender siblings of mature plants, offer a great opportunity to enhance the nutritional value of our diets. Beyond their nutritional significance, microgreens are gaining recognition for their organoleptic characteristics and commercial value in the modern age of science and technology. This study focused on the cultivation and nutritional analysis of microgreens grown in various media, including coco peat, vermicompost, tissue paper, and hydroponic media. The study aimed to explore the potential of microgreens as sources of minerals and nutrients in a balanced human diet, with specific attention to vitamins, ß-carotene, and minerals.

The results indicated that microgreens, when grown under controlled conditions, can indeed serve as rich sources of essential nutrients, including vitamin C, B complex vitamins, and ß-carotene. Different media were found to be suitable for specific microgreens, with coco peat and vermicompost emerging as ideal choices for certain crops. Hydroponic media also demonstrated its versatility in supporting the growth of various microgreens. The study highlighted the need for further research in this area, particularly regarding the influence of light on microgreen growth and nutrition, improved washing and drying techniques, and the bioaccessibility of nutrients.

Moreover, the study introduced innovative culinary recipes that incorporated microgreens, such as Uthappa, Pulav, Potato Tikki, Idli, Sarvapindi, and Sweet Potato preparations. These recipes were well-received in pilot consumer tests and showcased the potential of microgreens to enhance the nutritional and organoleptic properties of dishes.

Nutritional Significance: Microgreens are valuable sources of essential nutrients, including vitamins, ß-carotene, and minerals. Their consumption can contribute to a balanced and nutrient-rich diet.

Media-Specific Growth: Different types of media, such as coco peat, vermicompost, tissue paper, and hydroponic media, can support the growth of specific microgreens. Selecting the appropriate medium is essential for optimal cultivation.

Versatile Hydroponics: Hydroponic media demonstrated versatility in supporting the growth of various microgreens, making it a suitable choice for cultivation.

Culinary Innovation: Culinary recipes incorporating microgreens can enhance the nutritional and sensory qualities of dishes. These recipes have the potential to diversify the use of microgreens in culinary applications.

There is ample scope for further research in the field of microgreens, including investigations into the effects of light on growth and nutrition, improved postharvest techniques, and studies on the bioaccessibility of nutrients. Additionally, clinical parameters and therapeutic applications of microgreens warrant further exploration.

In conclusion, microgreens hold promise as a valuable component of our diets, offering a range of health benefits and culinary possibilities. Continued research and innovation in the cultivation and utilization of microgreens can contribute to improved nutrition and overall well-being.

FUTURE RESEARCH DIRECTIONS:

Most microgreen research has been conducted by a small number of researchers in conjunction with relatively narrow focus areas. There is a vast amount of territory yet to be explored. Few species of microgreens have been studied and have not necessarily correlated with the varieties most likely to be commercialized. The effect of photoperiod on microgreen growth and nutrition has been largely overlooked. Similarly, the effect of cool night-time temperatures on plant growth, nutrition, and food safety of microgreens has not been assessed. Identifying prevention and intervention treatments that are beneficial for maintaining both quality and safety of microgreens is still in its infancy.

It is certainly clear that postharvest light treatments can enhance the formation bioactive components, but this has not been systematically studied to optimize nutrient content in a full range of potential microgreens. Augmenting phytonutrient content could provide inherent resistance to quality and safety issues. There are many postharvest treatments that have been explored for other produce items that may help to maintain quality and extend shelf life of microgreens. Optimizing washing and drying techniques for delicate greens or finding alternative technologies would be of great value to produce ready-to-eat microgreen products.

It is particularly important that the fundamental research into ensuring the safety and quality of this new addition to healthy diets is done so that the produce industry can avoid some of the problems that have challenged the mature produce and sprout industries during the past several decades.

NASA scientists have begun to explore the challenges and benefits of growing microgreens in space. Plants are highly valued in space to regenerate oxygen, fix nitrogen, provide vital nutrients and fresh ingredients, and to enhance morale of astronauts during extended stays away from earth (Kyriacou, De Pascale, Kyratzis, & Rouphael, 2017). Microgreens are ideally suited because of their low space, nutrient and growth medium requirements and shorts growing period. Growing food in space holds many challenges with regard to microgravity including seed germination, watering plants, and anchoring plant roots, as well as limited resources. Padgett (2018) describes the production and testing of films to hold seeds in place during cultivation. Vanderbrink and Kiss (2017) suggest that microgravity may even affect epigenetic processes and consequently gene expression in plants. Additionally, food safety concerns are paramount for astronauts who have limited access to medical treatment during space travel and are confined together in a small space. Seeds must be sanitized to ensure that they do not harbour human pathogens (Padgett, 2018). A final field of research that has not been specifically explored is new uses, e.g. foods or ingredients from wasted microgreens or microgreens at shelf life end. Even though shelf life extension of microgreens is critical, and has been summarized in this review to reduce waste, novel processing and reformulating of wasted microgreens into new products is a future research direction.

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Appendix-I

Tips to Store Micro greens properly:

Most of the time, we can't finish a whole tray of microgreens right away and have to store them in the fridge. These short-life and perishable crops are high in nutrition when freshly harvested. If didn't store properly, they will be spoiled very quickly in a matter of hours.

1. The Good Cut With Ceramic

The first tip for you is to use a ceramic knife or ceramic scissors like this one here when harvesting the microgreens. Unlike metals, ceramic knife is lighter, non-toxic and chemically inert to the microgreens. That's to say, it doesn't transfer ions to the cut end of microgreens, which leads to a faster oxidation process (turning brown).

2. Cool Down And Sterilize:

Next, prepare yourself a sink of ice-cold water, and mix 1 teaspoon (200 ppm) of regular bleach into the water. Then, wash the microgreens briefly in it. Also, you can use the food-grade 3% hydrogen peroxide to achieve the same result. This step is to slow down the biological processes in plant and also to sterilize the microgreens from mould problems so to have a longer storage time.

3. Airflow and Moisture:

When storing microgreens in the fridge, do not use a sealed bag. Microgreens degrade and spoil quicker under that condition. To keep them as fresh as possible, air circulation and moisture are both the important factors as well. So, you should use an opened container instead. Meanwhile, you can lay a piece of wet paper towel on the container and cover another one on top of the microgreens. Also, it's important to know that light exposure while storing microgreen in the fridge can accelerate the deterioration.

4. Desirable Temperature:

Normally, the microgreens can be kept in the fridge for a week or so. That's said, your fridge should be maintained at a temperature of ~4°C (or 40°F). Do not put them in the freezer. According to a research study [1], it's found that microgreens that were stored at 40°F can last anywhere from 14 – 21 days, while those that were stored at 50°F would have a shelf life reduction to 7 – 14 days. Out of others, radish microgreens have a better shelf life. Constantly opening and closing the fridge can fluctuate the temperature as well. So, if you notice some white spots, foul smell, or slimy touch, just throw them away.

How to Dehydrate Your Microgreens

This part is simple if you're using a dehydrator. After you clean and dry them as detailed above, you just dehydrate them the way you would another fruit or vegetable. From there, you can keep them whole, grind them into a powder, or make them into flakes to sprinkle into soups.

If you're using your oven, here's what to do:

a) Clean and dry your microgreens as detailed above
b) Set your oven at its lowest temperature – ideally, 180*F, but anywhere below 200*F works
c) Let it stay in the oven for six to ten hours, monitoring the microgreens from time to time
d) You can keep them in an airtight container like a glass jar after that without needing refrigeration. They can last up to five years before going bad!

Bottom line: Dehydrating microgreens is a good option for people who don't mind processing their greens a little more at the outset or for people who want their greens to be extremely shelf-stable.

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