II REVIEW OF LITERATURE

The review of literature pertaining to the study entitled, **"Cultivation and Nutritional Profiling of Selected Varieties of Microgreens and their Acceptability in Incorporated Recipes"** is discussed under the following headings

- **2.1. Cultivation and Growth of Selected Microgreens**
- **2.2. Therapeutic Role of Microgreens**
- **2.3. Role of Green Leafy Vegetables in the Management of Common Diseases and Disorders**
- **2.4. Importance of being Healthy**
- **2.5. Culinary aspects of Microgreens**
- **2.6. Awareness on Microgreens**

2.1. Cultivation and Growth of Selected Microgreens

Another type of distinctive crop is micro greens, sometimes known as "Vegetable Confetti." Micro greens are described as delicate juvenile greens grown from cereals, vegetables, herbs, or wild types of plants. Because of the rising popularity of gourmet cooking, healthy eating, and indoor gardening in developed nations, microgreens are now well known there. Even when kept in the refrigerator, this novel cuisine has a rather short shelf life and is only seldom used as seasonings, toppings, or garnishes (Riggio *et al.,* 2019).

Gioia *et al.,* (2015) depicts that malnutrition issues are a serious distress that must be eradicated from society. Researchers in nutrition are concentrating on the requirement of a diet with pure, nutrient- rich, and higher amounts of essential nutrients, including minerals, vitamins, and phytochemicals for healthy body growth. In this situation, the vegetable business has developed new, creative ways to produce Micro Greens (MGs). The MGs are innovative in the sense that they have the capacity to update the entire concept of vegetables and the vegetable business as a whole.

These eco-friendly microgreens have lately gained popularity as garnishes and toppings in restaurants, demonstrating their capacity to enhance the organoleptic qualities of foods while also enhancing customer service. The overall reputation of microgreens was strongly based on taste acceptability, and consumer acceptance of all microgreens varied from acceptable to outstanding. According to information now available, microgreens are rich in trace elements and bioactive compounds, and their top grade may be superior to that of their grown counterpart (Kyriacou *et al.,* 2016).

Microgreens are an uncommon variety of edible greens that may be found at upmarket shops and eateries. Over the past few years, they have become a trendy new culinary fad (Murphy *et al.,* 2010). Tender immature greens known as microgreens are grown from the seeds of vegetables and herbs. They have two completely formed cotyledon leaves, either with or without the appearance of a pair of first genuine leaves (Treadwell *et al.*, 2010).

Paradiso *et al.,* (2018) reported that a few days or weeks after germination, during the formation of cotyledons and the appearance of the first true leaves, micro greens are harvested. They are characterized by a variety of colors, tastes, and textures and are fresh and tenderly soft vegetables, found fromthe seeds of abundant varieties (aromatic herbs vegetables, wild edible plants, and herbaceous plants.

Many fruits, vegetables, cereals, and herbs, primarily those in the Brassicaceae, Lamiaceae, Amaryllidaceae, Apiaceae, Amaranthaceae, Cucurbitaceae, Fabaceae, and Asteraceae families, contain immature, fragile cotyledonary leaves, including hypocotyl, which are known as microgreens (Choe *et al*., 2018, Kyriacou *et al.,* 2016).

Renna *et al*. (2017) opines that depending on the kind are growing, they are harvested between 10 and 20 days after seedling germination and are made up of cotyledons (seed leaves), beginnings, and originally actually went down leaves. They are also becoming more well-known due to their range of delicious flavours, textures, and tones, as well as their high standards for quality.

Microgreens typically grow to a height of 2.5–7.6 cm (1–3 in), are harvested 7–14 days after germination, and are sold with the stem and connected cotyledons (seed leaves). Microgreens, despite their diminutive size, may offer a wide variety of potent aromas, vibrant hues, and soft textures (Lee *et al.,* 2009). In order to improve the colour, texture, and/or flavour of salads, soups, and sandwiches, microgreens can be added as a newelement. They can also be added to a wide range of major courses as an edible garnish (Lee *et al.,* 2004).

Some immature seedlings may have substantially greater amounts of vitamins, minerals, and other health-promoting phytonutrients than mature leaves. According to a recent research by Lester *et al.,* (2010), the younger leaves of baby spinach (*Spinacia oleracea L*.) often have greater quantities of phytonutrients, including the carotenoids lutein, violaxanthin, zeaxanthin, and beta-carotene.

Oh *et al.,* (2010) also discovered that, compared to older leaves, immature lettuce *(Lactuca sativa*) seedlings had the highest total phenolic content and antioxidant capacity 7 days after germination.

Since microgreens have a higher nutritional value and a more potent flavour and taste than sprouts, they might be thought of as superior alternatives (Puccinelli *et al.,* 2019). In addition, compared to their mature counterparts, microgreens may have greater levels of phytochemicals, minerals, and vitamins (Yadav *et al.,* 2019 and Xiao *et al.,* 2012).

Therefore, including microgreens in diets may enhance the nutritional value and help consumers achieve better health results. Microgreens are exceedingly sensitive and often have a limited shelf life, which has caused several difficulties for farmers and the supply chain (Puccinelli *et al.,* 2019). Numerous pre- and post-interventions have been researched to increase the nutritional content of microgreens and lengthen their shelf life. Overall, research on the nutritional value and health advantages of microgreens is still in its infancy because they are a relatively new speciality commodity (Allegaetta *et al.,* 2019).

i. History of Microgreens

The origins of microgreens, such as young leafy vegetables, began as a culinary craze associated with high-end restaurants and their desire for heirloom, locally sourced, and distinctive foods (Bliss *et al.,* 2014; Verlinden, 2020). Even though, young green vegetables have always been a staple of our diet; the brief ascent of fresh micro produce transported across great distances is a more recent development. A farm that began in its current form inthe 1980s, Chef's Garden is one of the most popular micro vegetable providers in the US (Lubow, 2006; Verlinden, 2020). In spite of this, tiny and big greenhouses alike produce microgreens nowadays.

Lenzi *et al.,* (2019) opines that microgreens are among the most often used crops in controlled environment agriculture because they may be grown in soil or hydroponically, which is the most common indoor farming technique. Vegetable greens that have not yet grown cotyledonary leaves arecalled microgreens. Microgreens have been grown in Southern California since the 1990s, and in the last ten years, their fresh flavor and nutritional advantages have expanded their appeal.

Microgreens originally appeared on menus in San Francisco, California, in the early 1980s. Even though interest in microgreens has increased since they were first introduced into high-end kitchens in the late 1990s, restaurant chefs continue to be the major market (Choe *et al.,* 2018). According to a 2018 analysis by Kaiser & Ernst, the direct availabilityof microgreens in supermarkets and specialty retail outlets has driven higher demand for them.

Microgreens have entered the mainstream during the 2000s as demand for functional foods that promote health and lifespan has grown significantly (Kyriacou *et al.,* 2016; Verlinden, 2020). Their production in small-scale, diversified agricultural activities is now widely supported (Treadwell, 2013; Alexander 2016; Verlinden, 2020). Sometimes combined with certain products such edible flowers and sprouts (Eber, 2012; Verlinden, 2020). For the purpose of producing microgreens commercially, many species were examined and employed.

Yanes (2019) reported that since their introduction, microgreens have received great customer reactions, and also their general appeal has a close relationship with taste repute. While all eco-friendly foods are eaten when they are young, microgreens and sprouts should not be confused. While microgreens grow in light difficulties along with dirt, sprouts grow in moist and dark environments. As a consequence, compared to sprouts, microgreens contain a greater concentration of nutrients and a lower level of microbial contamination.

ii. Varieties of Microgreens

Since the availability and consumption of microgreens are significantly influenced by the emergence of culinary trends, the species' selection relies on manufacturer discussions with chefs and on consumer acculturation to their unique sensory qualities. Microgreens can be distributed as freshly cut foods as well as while growing on medium for end users to harvest.

The vast majority of species and cultivars utilized in today's microgreen production are members of the Brassicaceae and Amaranthaceae families. Beet, chard, and amaranthus in the Amaranthaceae family and radish, broccoli, kale, cabbage, tatsoi, pakchoi, mizuna, arugula, and mustard in the Brassicaceae family are some of the most well-liked species, subspecies, and variants (Renna *et al.,* 2018).

Verlinden (2019) highlighted that additionally growing in microgreens like grain crops include buckwheat, wheat, andrye. In addition, a number of herbs, both culinary and medicinal, have been employed in the manufacture of microgreens. Among many other herbs, there are borage (or starflower), parsley, basil, and fenugreek.

The most often exploited species are those belonging to the groups Brassicaceae, Asteraceae, Chenopodiaceae, Lamiaceae, Apiaceae, Amarillydaceae, Amaranthceae, and Cucurbitaceae. Bioactive substance is noticeable in several types of very harsh tastes (like Brassicaceae), and its varying adequacy necessitates identifying proof of genotypes that maytake needs for both flavor and wellness into account (Xiao, Lester *et al.,* 2012).

Different Microgreens and the Type of Bioactive Compounds present in them:

Table I

Bioactive Compounds Present in Different Microgreens

Common Name	Family	Scientific Name	Bioactive Compounds
Broccoli	Brassicaceae	*Brassica oleracea var.italica*	50 times more sulforaphane
Basil	Lamiaceae	*Ocimum sanctum L.*	Total ascorbic acid, phylloquinone, carotenoids,tocopherols, and total phenolics
Beet	Amaranthaceae	*Beta vulgaris L.*	Sensory attributes
Cabbage	Brassicaceae	*Brassica oleracia L. varcapitata L.*	Ascorbic acids, carotenoids, phylloquinone, and tocopherols,
Carrot	Apiaceae	*Daucus carota*	Anthocyanins andcarotenoids
Cauliflower	Brassicaceae	*Brassica oleracia L. varbotrytis L.*	Polyphenols, anthocyanins,flavonol, glycosides, hydroxycinnamic acid, and hydroxybenzoic acid
Chickpea	Fabaceae	*Cicer arietium L.*	Anthocyanins, ascorbic acids, phytochemical content, and antioxidant activity
Celery	Apiaceae	*Apium graveolens L.*	Sensory quality, phytochemical content, and antioxidant activity
Fenugreek	Fabaceae	*Trigonella foenicum-graecum L.*	Sensory quality, phytochemical content, andantioxidant activity
Radish	Brassicaceae	*Raphanus sativus*	Ascorbic acids, carotenoids,total sugars, phylloquinone,and tocopherols,
Green gram	Fabaceae	*Vigna radiata*	Anthocyanins
Spinach		*Spinacia oleracea L.*	Vitamins C, B9, K1, andcarotenoids
Lettuce		*Lactuca sativa*	Total phenolic concentrationand antioxidant capacity

Sometimes, legumes like chickpeas, beans, and lentils as well as grains like rice, oats, wheat, corn, and barley are produced as microgreens. Depending on the type of green, microgreens can have flavors that range from mild to spicy, acidic to even bitter. Inessence, their flavor is meant to be intense and concentrated (View and Club, 2019).

iii. Microgreens Vs Sprouts

Riggio *et al*. (2019) reported that microgreens may sometimes be confused with sprouts, which have frequently been linked to food-borne illness, despite the fact that they share certain traits with freshly chopped herbs (such as basil, thyme, and cilantro), small greens (such as baby spinach and spring mix), and sprouts. Since 2009, very few reports have specifically examined the food safety risks of microgreens, while numerous studies have been conducted worldwide to investigate the safety of leafy greens and sprouts. Many research studies have discussed the nutritional and physiological characteristics of microgreens.

Although taken in an immature state, microgreens and sprouts are different from one another (Treadwell *et al.,* 2013). Sprouts are often raised in wet, dark environments that are conducive to microbial growth, and their utilisation in foodborne epidemic outbreaks has been distinct from that of micro- and baby-greens. Additionally, microgreens have more taste-enhancing qualities than sprouts and a wider variety of leaf colour, shape, and variety. Numerous recent studies have revealed that microgreens contain lower nitrate contents than fully developed vegetable leaves and greater concentrations of minerals (Calcium, Magnesium, Iroon, Manganese, Zinc, Selenium, and Molybdenum) and phytonutrients (ascorbic acid, b-carotene, a-tocopherol, and phylloquinone) (Xiao *et al.,* 2012).

iv. Production of Microgreens

People are now becoming more and more aware of the value of microgreens. Therefore, people in rural, urban, and peri-urban areas may take advantage of the nutritious potential of microgreens at home and in the market. Although cultivating microgreens is fairly simple, there are certain commercially important parameters that must be met for microgreen production to be successful (Kumar *et al.,* 2015).

Gioia and Santamaria, (2015) presented that the main producers are in North America and Europe. Microgreens may be grown from any grain or seed. Monocotyledons and di-cotyledons are two types of grains that are utilised to make microgreens. They need a lot of light, especially direct sunshine, with little humidity and adequate airflow. 1 seed/cm^2 for species with big seeds such peas and chickpeas, and up to 4 seeds/cm^2 for species with tiny seeds, including cabbage, broccoli, radish, and amaranth.

Microgreens are an excellent source of many different nutrients and are environmentally beneficial. Microgreens can grow in 10 to 2 weeks. Microgreens are frequently grown using soilless slicing techniques, where the soil is replaced by a substrate or a liquid tool (Singh *et al.*, 2014).

Di Gioia as well as Santamaria, (2014) opines that microgreens can be easily produced in a variety of settings and can be done professionally using cutting-edge techniques to ensure product quality and consistency, or at a non-professional level, for one's own consumption, using incredibly basic methods and techniques and even in incredibly small spaces, like a windowsill.

Microgreens may be cultivated at home by individuals. Small-scale home gardening can be rather simple, but commercially producing and selling high-quality microgreens is exceedingly difficult. The appropriate blend at the ideal harvest stage is one of the most important production methods for success. From sowing to harvest, different crops require quite different amounts of time (Tan *et al.,* 2020).

Bulgari *et al.,* 2017 depicts that growers should choose crops with comparable growth rates when growing a variety of crops in a single planting flat so the entire flat may be harvested at once. Growers can also sow each crop separately and combine them after harvest.

It can be cultivated in a typical sterile, loose, soilless germination medium, which has been successfully utilized with peat, vermiculite, perlite, and coconut fibre. The second half of the tray is then filled with the desired media to a depth of 12 in. to 1 or 2 in., depending on watering schedules. In this media system, overhead mist watering is typically employed and utilizes one or more materials as a mat or liner that is put in the bottom of a trayor is made to be longer using a different production method. These substances typically resemble fibers and provide a great seeding bed. For some crops, the mat could be adequate on its own or it might just need a minor topping with a medium after sowing. One can seed in rows or using a spread technique (Weber *et al.*, 2017).

Tan *et al.,* (2020) given that approving seeding density is challenging. The majority of farmers say they want to seed as densely as they can to optimise productivity, but not too densely because doing so favours lengthened stems and raises the danger of disease. In the majority of crops, the seed supplies sufficient nourishment for the early crops, necessitating little or no fertiliser. Some longer-growing microgreens crops, such microcarrots, dill, and celery, may benefit from a little fertiliser application to the tray bottom.

Some of the faster-growing greens, like chard and mustard cress, may also gain from light fertilisation since they sprout quickly and burn up their own reserves of nutrients. The ideal way to apply light fertilisation is to float each Microgreen tray for 30 seconds in a prepared nutrient solution with around 80 ppm nitrogen (Libo *et al.,* 2019). In the greenhouse, seeds can be planted on a variety of surfaces and germinated on benches with above, sub, or germination chamber watering (Bliss, 2014).

At home, there are two ways to grow microgreens: hydroponically and in soil. Before covering the bottle and the initial seed with tissue paper, the seed should soak overnight. Ensure that top cells come into touch with water from below in indirect sunlight; additional containers are also situated immediately beneath the main container. One to three inches of wet soil can be kept and also frequently leveled with gentle pressure in order to develop the soil-based small eco-micro greens. The pre-soaked seeds can either be lightly pushed into the soil or sprayed on top of it. Water will undoubtedly be sprayed on the tissue sheet once or twice a day to keep it wet (Gioia *et al.,* 2014).

According to Benke *et al.,* (2016), commercial cultivation of microgreens can be done by the cloth mat may be adequate on its own, and also a light coating with a tool may be necessary after planting. Both batch and real-time seeding are possible. Utilizing seeding density referrals is difficult. Many farmers believe that they should seed as heavily as possible to increase productivity, but they do not want to seed too heavily since crowding causes extended stems and increases the risk of sickness. Many plants don't require much, if any, plant food since the seed is enough to feed the young plant. Dill and mini carrots are two microgreen plants that may survive for a very long time.

v. Growing Media

There are several mediums in which to cultivate microgreens. Some growers use perlite, while others prefer blends (Johnson 2012 and Verlinden, 2020). (Gioia *et al.*, 2016, Verlinden, 2020). Early growth on filter paper has been employed in experimental settings to evaluate additives to the germination media, such as leftover brewer's yeast (Lobiuc *et al.*, 2017, Verlinden, 2020). Most growers prefer peat-based mixtures or synthetic mats. Sand, peat, coconut coir dust, sugarcane filter cake, and vermiculite have also been examined as ingredients in composts (Anon, 2016, Verlinden, 2020). All were successful at growing microgreens (Muchjijab *et al.*, 2015).

The growth and insert trays, humidity domes, and micro-mat hydroponic growing pads required to cultivate microgreens were purchased from Handy Pantry. In each of the 15,5" 5" insert trays containing vermicompost or micro-mat hydroponic growingpads, 5 grammes of broccoli seed was planted. During the trials, sterile deionized water was used to hydrate the seedlings in five insert trays containing vermicompost and five insert trays containing hydroponic growth pads (Weber, 2017). In 0.5 L plastic vessels, microgreens from the Brassicaceae family, including kohlrabi, mustard, red pak choi, tatsoi, basil, and parsley, were cultivated for 10 to 19 days from planting to harvest (Samuoliene *et al.*, 2013).

The substrate included the following nutrients in the following amounts: N 110, P2 O5 50, and K2O 160 (measured in mg L 1). (used as mg L -1). Basil and parsley seeds weighing 1 g and 2 g, respectively, were sown into each vessel. Experiments were carried out in controlled-environment growth chambers according to the size and weight of seeds sown per vessel. With a 16-hour photoperiod and 50–60% relative air humidity, day/night temperatures of 21°C were established (Samuoliene *et al.*, 2016). In a floating hydroponic system, microgreens were also cultivated.

Bulgari *et al.,* (2017) reported that vermiculite-filled polystyrene cell trays were used to plant the seeds in. In a climate room kept at a constant 24°C and in the dark, seeds germinated. Rocket seeds began to sprout after two days, but it took basil and Swiss chard seeds three days to sprout. A polyethylene (PE) tank (30/60/6.5cm3) containing each 5 L of half-strength Hoagland nutritional solution was used to transfer the trays after germination. Initial distilled water preparation yielded a pH of 5.56 and an initial electric conductivity of 1.12 ms cm-1.

vi. In Greenhouse

Microgreens may be cultivated year-round in a greenhouse with supplementarylighting and home heating, providing a variety of outcome lengths. In a cleaned and also loosening soilless growth instrument, microgreens can be cultivated. Depending on watering strategy, half-fill a tray with your desired tool (Samuolien *et al.,* 2017).

vii. Light Effect

Zhang *et al.,* (2020) highlighted that Light is one of the most crucial environmental components for plants since it fuels photosynthesis and serves as a signal for a wide range of physiological reactions. The four key elements of light conditions are direction, photoperiod (duration), light quality (wavelength), and light quality (intensity). The study of the effects of light on the nutritional quality of sprouts and microgreens is made easier and more conclusive by the use of artificial light sources (such as fluorescent lamps, halogen light, LED light, and high pressure sodium lamps), which emit photons over a spectral range from 250 nm to 750 nm.

The generation of secondary metabolites and physiological change in plants are significantly influenced by the light environment. Variation in the irradiance levels and artificial lighting spectra can have an impact on growth and nutrition. One of the most promising energy-efficient and quickly evolving plant illumination solutions to date is light- emitting diodes (LEDs). Combinations of red, blue, and far-red LED light wavelengths are said to be effective for growing sprouting seeds, Microgreens, wheatgrass, and mature lettuce plants (Anon., 2016).

The current study's goal was to identify the lighting conditions required to promote better nutritional values in plants by examining the effects of LED light intensity on the growth and antioxidant qualities of microgreens from the Brassicaceae family. Experiments were conducted in a growing chamber with a controlled atmosphere (Samuoliene *et al*., 2013). Depending on the species and occasionally the variety, light intensity and quality can have different effects. For instance, whereas red pak choi and tatsoi acquire carotenoids under blue, red, and far-red lighting, green light can boost carotenoid accumulation in mustard microgreens (Brazaityte *et al.*, 2015).

The generation of secondary metabolites in plants is greatly influenced by the light (Lefsrud *et al.*, 2006). Recent research suggests that altering the light's intensity can boost the nutrients found in microgreens, including carotenoids, tocopherols, glucosinolates, and minerals (Kopsell *et al.*, 2012). In a research, Kopsell and colleagues investigated how light can raise zeaxanthin levels in mustard microgreens. Photosynthesis is a vital process for plants to use as a source of ongoing energy (Kopsell *et al.,* 2012). Photosynthesis involves the presence of carotenoids. Carotenoids are pigments that are incorporated into chloroplastsand act as free radical quenchers and heat dissipators (Frank *et al.*, 2003).

The xanthophyll cycle, which involves the carotenoids zeaxanthin, antheraxanthin, and violaxanthin, is required for the disposal of surplus energy. Plants convert violaxanthin to zeaxanthin via the xanthophyll cycle when there is an excess of absorbed light (Demmig*et al.*, 2003). According to a research, exposure to 463 mol photons/m^2/s for a brief period of time increased the antheraxanthin and zeaxanthin content of mustard microgreens by 50% and 133%, respectively. Similar research employing short-duration blue light exposures and broccoli microgreens discovered that the blue light caused increases in carotenoids, total glucosinolates, and minerals in the broccoli microgreens (Kopsell *et al.*, 2010).

Furthermore, more current investigations confirm the findings of these previous studies. Samuolien *et al*., (2013) examined the levels of carotenoids and tocopherols in three distinct microgreens while testing the impact of blue light on them. They claimed that higher blue lightintensities had a more significant impact on the buildup of carotenoid and photosynthetic pigments. When these findings are considered collectively, they demonstrate that light exposure is a crucial element in changing the nutritional profiles in microgreens. Tocopherols, however, were more susceptible to lower blue light dosages. The possible impacts of light exposure on nutrient accumulation in various microgreens and the underlying molecular biochemical pathways require more study (Marchesi *et al.,* 2016).

viii. Growing Conditions and their Effects on Growth and Nutrient Content of Microgreens

Weber (2017) defines that microgreens are not only simple to cultivate but also good suppliers of many different nutrients and are beneficial to the environment. For instance, microgreens may be grown in 10 to 14 days. In addition, a research claims that a broccoli microgreen has equal nutrients in 93–95% less time and 158–236 times less water than mature broccoli. Microgreens also don't require pesticides, fertilizers, or energy-intensive transportation fromfarm to table. Growing conditions are crucial because they have a direct impact on plant development and phytonutrient concentrations.

ix. Rate of Sowing Seeds

The pace of seed germination is crucial for plant development because it creates competition for scarce resources like nutrients and water. Murphy *et al.,* (2010) used arugulamicrogreens to evaluate four different sowing rates at 50.25, 100.5, 150.75, and 201 g/m2 based on the 201 g/m^2 commercial seeding rate. They discovered a linear association between sowing rate, shoots per square metre, and shot weight per square metre. However, when the seeding rate rose, the weight of each individual new shoot fell linearly. This represents resource rivalry among microgreens. Additionally, a study employing beet microgreens came to the same conclusion (Murphy *et al.,* 2010).

x. Fertilizers

Murphy *et al.*, (2010) depicts that fertilizers have long been utilized to provide plants with the vital nutrients they needto develop. As a consequence, calcium nitrate, ammonium nitrate, and urea had an impact on fresh weight per plant or m2. They discovered that these nitrogen sources produced more shoot fresh weight/m2 than ammonium sulphate in a different trial. Additionally, according to Murphy and others, combining pre-planting fertilization of the peat-lite mix (a soilless growing medium) with calcium nitrate at 2000 mg/L of nitrogen (150 mL/L of medium) with daily post-planting solution fertilization of 150 mg/L of nitrogen resulted in a significant increase in the yield of beet microgreens.

Additionally, using broccoli as a model vegetable, Sun and colleagues revealed the possible impact of calcium salt on the nutritional content of microgreens. The levels of glucosinolate in broccoli microgreens treated with and without calcium chloride varied. Surprisingly, broccoli microgreens treated with calcium exhibited higher amounts of glucosinolates than untreated broccoli microgreens, showing the possibility of improving microgreens' nutritional value by altering growth circumstances (Sun *et al.*, 2015).

xi. Harvest and Postharvest

Microgreens from each tray were collected 11 days after the first genuine leaves appeared by cutting the seedling slightly above the surface of the growth medium with a sterile knife. To calculate fresh shoot weight (FW) per unit area, harvested microgreens were weighed (Gioia *et al.*, 2016). The majority of species are harvested when the first real leaves show, when the cotyledons are completely developed, still turgid, and still have their characteristic colour, and when the seedlings are between 5 and 10 cm tall. Harvesting is done by manually or mechanically cutting the seedlings a few millimetres above the growth medium surface. Growing medium fragments and seed integuments, which in some species stay attached to the cotyledons, should be carefully avoided (Kyriacou *et al.*, 2016).

Wang and Kniel, (2016) reported that sprouts, on the other hand, are often younger and saturated in water, with only or barely opening cotyledons. Concern of a situation resembling the sprout boom arises with the growing consumption of microgreens.

Postharvest perishability is perhaps the biggest obstacle to the growth of the commercial microgreens industry. They need to be harvested carefully, which can be time- consuming, and quickly cooled to remove essential heat and slow the rate of respiration, rotting, and senescence. Microgreen production costs are strongly impacted by labor- intensive microgreen harvesting, especially when manufacturing is done in trays that need for harvesting using scissors. While planting on synthetic fibre, food-grade plastic, orburlap- like matting can assist better handling and quicker harvesting and chilling of the product, the use of loose substrate in trays slows down the harvesting process (Treadwell *et al.,* 2010).

To minimise the entry of pathogens through contaminated seeds or irrigation water, suggestions that are comparable to those for sprout formation should be made (Xiao *et al.,* 2014; Reed *et al.,* 2018; Wright & Holden 2018; Verlinden, 2020). Freshly cut leafyvegetables have been demonstrated to last less time in storage when using dull blades; similarly, harvesting microgreens requires the use of sharp blades to prevent bruising and harm to stem cells along the cut (Portella and Cantwell, 2001; Kyriacou *et al.,* 2016). Controlling humidity and excluding insects are crucial for the optimal development of microgreens. Harvesting is frequently done manually.

xii. Temperature and Storage

Xiao *et al.,* (2013) presented that microgreens are considered to be extremely perishable items since they are sensitive and have a short shelf life (1-2 days) at room temperature. One of the most important elements determining the postharvest physiology and storage behaviour of produce is storage temperature. By slowing down respiration rates, senescence, and the development of rotting microgreens, low-temperature storage can generally prevent quality loss and lengthen shelf life. The best temperature for storage depends on the fruit or vegetable. For some chilledsensitive fruits and vegetables, low-temperature storage has a negative impact on quality features and accelerates degradation. Therefore, choosing the ideal storage temperature is essential.

In order to conduct temperature investigations, microgreens were packaged (10g/bag) unwashed in polyethylene bags (15cm 15cm) with film OTRs of 8.0, 16.6, 21.4, and 29.5 pmol/ (m2s Pa) and kept at 5 C for 21 days. Evaluations were carried out on days0, 4, 7, 14, and 21 (Kou *et al.*, 2012).

xiii. Packaging

Sandhya (2010) reported that the use of modified atmosphere packaging (MAP), a method that successfullyextends the shelf life of fresh and little processed food including lettuce, broccoli, spinach, and mushrooms, allows for the preservation of product's freshness. Product respiration rate, packaging film oxygen transmission rate (OTR), product weight, packaging surface area, storage temperature, and relative humidity are just a few of the variables that affect howitems are packaged.

Mir *et al.*, (2017) given that micro greens are claimed to be highly decomposable items, but unfortunately, commercialization of them is limited due to their rapid deterioration and relatively short storage life, usually 3 to 5 days at room temperature. The improvement of their packaging and post-collection stockpiling conditions is therefore becoming increasingly important for extended periods of realistic usability as the demand for micro greens increases and, as a result, their appearance in farmer's markets and specialty grocery stores also begins.

2.2. Therapeutic Role of Microgreens

Microgreens contain more nutrients than mature leaves:

Microgreens are loaded in nutrients. Many varieties are rich in K, Fe, Zn, Mg, and Cu despite the concentration variations that may occur (Xiao *et al.*, 2016). According to Xiao *et al*. (2012), microgreens are an excellent source of important plant components like antioxidants. Additionally, they have concentrated nutritional value, meaning they contain more vitamins, minerals, and antioxidants per serving than the same amount of mature greens (Xiao *et al.*, 2012). According to studies, the nutrients in microgreens might be up to nine times more than those in mature greens (Pinto *et al.*, 2015).

According to Xiao *et al.*, (2012), red cabbage, cilantro, garnet amaranth, and green daikon radish micro greens have the highest concentrations of ascorbic acid, carotenoids, phylloquinone, and tocopherols, respectively. When compared to data base values for fully grown vegetable counterparts, micro greens also contain significantly more bioactive substances.

However, due to uncertainty regarding the growing circumstances, post-cultivation settings, and extraction methods for fully grown veggies, this early small-scale green research was limited. If we examine considerable effects of light wavelength and intensity on phytonutrient content, experimental data adds uncertainty as compared to database results. For instance, it may be problematic to draw conclusions from data pertaining to fully matured vegetables with head frames, when only the outer leaves are exposed to light (Xiao *et al.*, 2012).

Additionally, studies revealed that microgreens, as opposed to their fully developed veggie counterparts, contain antioxidants and variety of polyphenols (Bull, 2008). One study indicated that 25 commercially available microgreen has high levels of vitamins and antioxidants. Vitamin and antioxidant levels differed when compared to those recorded for fully grown vegetable leaves in the USDA National Nutrient Database, and it was estimated that the amounts found in microgreens might be up to 40 times higher (Xiao*et al.*, 2012).

According to a study on microgreens by USDA (2010), young lettuce seedlings that were harvested seven days after germination had the highest antioxidant capacity and the highest concentrations of phenolic compounds, which are known to promote good health, when compared to their more mature counterparts. A team of researchers from the University of Maryland and the United States Department of Agriculture examined the nutritional makeup of 25 commercially marketed microgreen variants a few years later. They found that, in comparison to mature leaves, microgreen cotyledon leaves typically had much greater nutrient densities (cotyledon leaves refer to the embryonic first leaves of a seedling).

Kou *et al.,* (2013) opines that the vibrant colours of microgreens are frequently utilized as garnishing ingredients. They may be added to salads, soups, sandwiches, spaghetti, noodles, and raitas as garnishes. Rotis, idlis, and dosa can be promoted and added to the morning breakfast menu by microgreens. People may add them to smoothies, bread omelette and khichidi, a variety of other culinary products including sandwiches, dhoklas, pizzas, etc. because of their appealing flavour, colour, and scent. To maintain their nutritional value in an Indian setting, they can be added to curries and dhal at the very end.

Micro greens are an increased supply of vital nutrients that support health maintenance. Urban populations are more prone to diet-related disorders since they interact with many climatic conditions, eat a lot of ready-to-eat meals and fast food, and don't get enough nutrition and exercise. Anemia, low BMI, and abnormal growth are signs of undernutrition, whereas non-communicable illnesses are signs of over nutrition. It is a well- known reality that people in metropolitan regions and rural societies alike don't have much time to focus on eating wholesome foods (Tamilselvi *et al.,* 2018).

However, according to current nutrition study by Pinto *et al.,* (2010), organic or microgreen foods that contain vital micronutrients for maintaining a healthy lifestyle should take precedence. In backyards or home gardens with the right conditions, microgreens are readily cultivated. If the temperature is between 18 and 25°C, there is enough light, and the days arelong enough, they can also be cultivated inside or in greenhouses. In communities with nutritional deficiencies, small-scale home production may be promoted.

i. Nutritional Benefits of Microgreens Total Sugar Contents

Xiao *et al.,* (2012) opines that the total sugar content of six microgreens, including bull's blood beet, China rose radish, Dijon mustard, opal basil, peppercress, and scarlet amaranth. The greatest sugar content per kilogramme was found in China rose radish, whichmeasured 10.3 g/kg. Peppercress, Dijon mustard, bull's blood beet, opal basil, and scarlet amaranth came in at 8.8, 7.7, 4.4, 2.0, and 1.7 g/kg, respectively. Vegetables that were ripe had more sugar than microgreens. For instance, the sugar content of mature peppercress and red amaranth was 44 and 17 g/kg, respectively (USDA, 2018).

ii. Glucosinolate

General desulfoglucosinolate concentrations in microgreens are much higher (17.15 mol/ g totally dry weight) than in mature counterparts (8.30 mol/ g fully dry weight), according to a red cabbage microgreen research testimony. In the United States and other areas of the world, obesity, cardiovascular disease (CVD), and type 2 diabetes are serious chronic conditions. These conditions are commonly linked to diets that are high in calories, fat, and fruits and vegetables (Choe *et al.,* 2018).

iii. Provitamin A

Xiao *et al.,* (2013) reported that among the microgreens tested, red sorrel had the greatest concentration of carotene (12.1 mg/100 g fresh weight (FW)), followed by cilantro, purple cabbage, and pepper cress (11.7, 11.5, and 11.1 mg/100 g FW, respectively). Cilantro microgreens produce three times as much - carotene as fully grown and mature cilantro leaves. Approximately 260 times the value (0.44 mg/100g FW) tape-recorded for fully grown purple cabbage, or 11.5 mg/100g FW, is present in purple cabbage. All of the microgreens investigated are excellent sources of - carotene, with the exception of the green and yellow maize shoots.

iv. Carotenoids

Despite the fact that all 26 microgreens tested positive for the carotenoids lutein and zeaxanthin, cilantro had the highest concentration of lutein/zeaxanthin at 10.1 mg/100 mg fresh weight (FW). The next three microgreens, with values of 8.8, 8.6, and 8.4 mg/100 g FW, respectively, were red sorrel, purple cabbage, and amaranth. These values were higher than those of completely mature spinach, which contains increased levels of lutein and zeaxanthin (7.2mg/100g FW) (Xiao *et al.,* 2013).

v. Vitamin C

Xiao *et al.,* (2013) highlighted that an ascorbic acid ranges from 20.4 to 147.0 mg/100 g fresh weight (FW) overall in microgreens. It was determined that the amount of vitamin C present in purple cabbage microgreens (147.0 mg/100 g FW) was 24 times greater than the estimated daily requirement for ascorbic acid. This amount of vitamin C was 6 times greater than data from prior publications of an expanded purple cabbage (24.4 mg/100 g FW) (Singh, 2006) as well as 2.6 times better (57.0 mg/100 g FW) registered in the USDA dietary information resource for common reference (USDA, 2011). Therefore, it was suggested that fresh microgreens are a great source of ascorbic acid (vitamin C) and may even be significantly more rich in ascorbic acid than theirfully grown plant equivalents.

A great source of vitamin C, an antioxidant that helps shield your body from the damaging effects of free radicals, is young edible seedlings. Even the microgreen sample with the lowest amounts of vitamin C included a remarkable 20 milligrams of vitamin C per 100g, which is about twice as much vitamin C as is present in tomatoes, according to a 2012 research on microgreens by USDA. Among the examined kinds, red cabbage microgreens exhibited the greatest amounts of vitamin C, with a 100g serving giving 147mg, or 245% of the recommended daily intake, of this essential component. According to information from the U.S. Department of Agriculture, a similar-sized serving of mature raw red cabbage has 57mg of vitamin C.

vi. Vitamin E

Vitamin E: Radish "daikon" contains significant amounts of -tocopherol, with 87.4 mg/100 g fresh weight (FW). Additionally, cilantro microgreens, radish "opal," and pepper cress are all excellent sources of -tocopherol and -tocopherol, with -tocopherol concentrations ranging from 41.2 to 53.1 mg/100 g FW and -tocopherol values ranging from 12.5 to 16.7 mg/100 g FW. Compared to its fully grown equivalent, purple cabbage microgreens have more than40 times the amount of vitamin E (0.06 mg/100 g FW) (Xiao *et al.*, 2013).

Scientists from Yale University demonstrated in 1967 that immature pea seedlings cultivated in light contain appreciable amounts of tocopherol (vitamin E). Similar findings were made by the scientists behind the 2012 microgreen study, who discovered significant tocopherol levels in the examined greens. Alpha-tocopherol and gamma-tocopherol concentrations per 100 grams varied from 7.9 to 126.8 milligrams, with green daikon radish microgreens having the highest value. If you consume only a modest bit of daikon radish microgreens each day, you would get your recommended daily allowance of 15 milligrammes of alpha-tocopherol, which is an essential antioxidant vitamin.

vii. Vitamin K

According to the USDA nutritional information resource (2011), the amount of phylloquinone, also known as vitamin K1, was 1.14, 0.41, and 0.04 g/ g fresh weight (FW), respectively, in fully expanded edible sections of amaranth, basil, and red cabbage, which were slightly smaller in size (4.09, 3.20, and 2.77 g/ g FW, specifically) than their corresponding microgreens. Four of the 26 microgreens evaluated had levels of phylloquinone equivalent to those in dropping leaf spinach, which is often regarded as an outstanding source of vitamin K1. This suggests that the majority of the 26 microgreen varieties will function as an exceptional supply of vitamin K1 (Xiao *et al.*, 2013).

According to the research conducted by the College of Maryland, the ratios of phytonutrients in different microgreens are quite diverse. The cotyledons of microgreens have a larger dietary thickness when compared to the fully-grown dropping leaves of the nutritional focus recorded in the USDA dietary data source (Xiao *et al.*, 2013).

Minerals are necessary nutrients for humans, and certain minerals are very important nutrients. Microgreens offer remarkable mineral resources, according to recent studies. According to Weber, compost-grown broccoli microgreens possessed 1.15 to 2.32 times the amount of phosphorus, potassium, magnesium, manganese, zinc, iron, calcium, salt, and copper that fully grown broccoli had. Different mineral concentrations have been found in three kale cultivars at various stages, including microgreen, infant leaf, and fully developed, by (Waterland *et al.*, 2017). They found that on a full plant, the dietary mineral emphasis was larger in the beginning of leaf development.

The study done by Yale University (2013), highlights that pea microgreens, or early pea seedlings as they were then known, also found that when the seedlings were exposed to light, they began to create significant levels of vitamin K. But it's not exactly a big deal. When chlorophyll, which is prevalent in all green plants, including microgreens, absorbs sunlight to create carbohydrates and oxygen during photosynthesis, vitamin K works as an electron acceptor. Humans can benefit from vitamin K's health advantages by supporting healthy blood coagulation and reducing excessive bleeding. Additionally essential for keeping robust and healthy bones is vitamin K.

According to a study by Xiao *et al*., (2012), the greatest concentrations of vitamin K were identified in amaranth microgreens. Phylloquinone is a form of vitamin K generated byplants (Red Garnet variety). The levels ranged from 0.6 to 4.1 micrograms per gram of vitamin K, which found to be significantly different amongst various microgreens.

viii. Bioactive Components

Red cabbage (Brassica Oleracea L. var. capitata), sorrel (Rumex acetosa L.), peppercress (Lepidium bonariense L.), and a few other microgreens varieties with less appetising flavours like amaranth (Amaranthus hypochondriacus L.) and cilantro (Coriandrum sativum L.) are examples of those that typically describe the bioactive amount (Xiao *et al.*, 2012). Carotenoids (violaxanthin, -carotene, and lutein/ zeaxanthin), ascorbic acid (free, total, and dehydro), tocopherols (- and -tocopherol), and phylloquinone are among the substances that have been proven to be bioactive in humans.

The bioactive substances found in microgreens may affect a variety of inflammatory pathways. Therefore, by following the swelling guideline, microgreens can help prevent diabetes, CVD, and weight issues. Red cabbage microgreens, as previously mentioned, tended to prevent weight gain brought on by a high-fat diet plan. The results of this microgreen may be related to its capacity to reduce adipogenesis, even though the system is ambiguous. Numerous phytochemicals found in vegetables and microgreens, including I3C and retinoic acid (RA), a metabolite of carotene, have been demonstrated to inhibit adipogenesis (Weber, 2014).

ix. Benefits of Microgreens in Diseases and Disorders

Consumer interest in health promotion has been the driving force behind the development of healthier food (low fat, low calories) with health-promoting properties (e.g., strong antioxidant activity, pro-/pre-biotics), even though the precise processes are still unknown. In light of this, new foods like microgreens have become available as dietary sources that may improve health (Olson *et al.,* 2004).

Diabetes and cardiovascular disease are among the non-communicable illnesses that cause the majority of fatalities in poor nations owing to a lack of wholesome diet. According to demographic, animal, and intervention research, eating a variety of veggies is a way to prevent certain illnesses. In a research employing red cabbage MGs on mice, Haiqiu Huang *et al.,* (2016) found that microgreens can alter weight growth, cholesterol metabolism, and reduce CVD issues by lowering hypercholesterolemia.

Eating microgreens is linked to a lower risk of numerous diseases because they contain large amounts of vitamins, minerals, and beneficial plant chemicals (Bazzano *et al.,* 2002; Carter *et al.,* 2010). Microgreens are likewise endowed with such essential elements that keep us healthy.

Kale and red spinach microgreens show somewhat stronger antibacterial activity than mature plants against a few pathogenic microorganisms. Utilizing red cabbage microgreens has been shown to reduce the levels of C-reactive protein (CRP) and tumour necrosis factor-alpha (TNF-) in the liver that are brought on by a high-fat diet. This result may be explained by the microgreen's capacity to control liver lipids, a large amount of which have been linked to inflammatory actions (Huang, 2016).

Renna *et al.,* (2017) depicts that diet has a significant role in microbiome law, and improvements can occur quickly. Eating microgreens could help regulate the intestinal microbiota because of their high flavonoid content. Additionally, microbial management of the bioactives in microgreens can change or enhance the performance of the microgreen biography. Consideration of the digestive tract microbiota's inflection and, consequently, protection from a number of illnesses linked to microbiome changes, is justified.

x. Prevention of Inflammation and Modulation of Immune Pathway by Microgreens

Numerous chronic illnesses, including as obesity, cardiovascular disease, and cancer, are caused by, originate from, or advance due to inflammation. As a result, controlling inflammation can have a significant influence on both managing health care expenses and the prevention of many illnesses. Inflammation is complicated, as are the immunological reactions connected to it (Laveti *et al.,* 2013).

According to Baldwin *et al.,* (2006), eating red cabbage microgreens reduced the liver's ability to produce tumour necrosis factor alpha (TNF-) and C-reactive protein (CRP), both of which are brought on by a high-fat diet. The capacity of the microgreen to reduce liver lipids, an excess of which has been known to trigger inflammatory reactions, may be the cause of this effect (Huang *et al.,* 2016).

In addition, one may examine some of the well- known pathways linked to inflammation to determine further possible impacts that microgreens may cause. For instance, many inflammatory stimuli appeared to be mediated through the nuclear factor kappa light chain-enhancer of activated B cells (NF-B) pathway. Through its capacity to trigger the transcription of genes associated with inflammation, NF- B plays a crucial part ininflammation.

Red cabbage microgreen investigation indicated that total desulfoglucosinolates concentrations in microgreens (17.15 μmol/g dry weight) were substantially greater than the mature equivalents (8.30 μmol/g dry weight) (Huang *et al.,* 2016). As one of the signalling channels that dietary glucosinolates are known to influence, NF-B is one of those pathways. It is thought that glucosinolates prevent the catabolism of the nuclear factor of kappa light polypeptide gene enhancer in B-cells inhibitor, alpha (IB), which prevents NF-B activation, even if a precise mechanism of action is still unclear (Takada., 2005).

Thus, the bioactive substances frequently identified in microgreens that regulate this important pathway may have an impact on immune/inflammatory consequences. Downstream of NF-κB, cyclooxygenase-2 (COX-2) is one of the key enzymes involved in inducing inflammation. Prostaglandin synthesis that might result in accelerated and uncontrolled inflammatory processes is controlled by COX-2 activation. Inflammation can now be treated with selective COX-2 inhibitors, a kind of nonsteroidal anti-inflammatory medication (NSAID). Numerous phytochemicals, including kaempferol, quercetin, and resveratrol, have been linked to studies that suggest they may inhibit COX-2 activity (Gracia *et al.,* 2007 and Subbaramaiah *et al.,* 2008).

Mittal *et al.,* (2014) found that microgreens may inhibit COX-2 activity because they contain flavonoids including kaempferol and quercetin. It is generally known that reactive oxygen species (ROS) regulate biological processes, including inflammatory pathways. ROS can have a variety of impacts on the NF-B pathway as well as other inflammatory signalling pathways. Reactive oxygen species (ROS) are known to be produced by inflammation as a defensive mechanism against pathogens including bacteria.

The control of ROS would have an impact on many aspects of inflammation. Numerous studies have been conducted on the bioactive antioxidant properties of diet. Vitamins C, E, and K, three conventionally recognised nutrients, have all been found to have antioxidant properties (Padayatty *et al.,* 2003, Traber *et al.,* 2007 and Burton *et al.,* 2001).

In the literature, it is also well established that the carotenoids and a large variety of polyphenols have antioxidant properties (Stahl *et al.,* 2003 and Scalbert *et al.,* 2005). Microgreens are well recognised for being high in these nutrients and micronutrients, as was indicated in the section on composition. As a result, microgreens may be able to directly or indirectly control immunological responses that are controlled by ROS, such as NF-B and other signalling pathways. The NF-E2-related factor 2 (Nrf2)-mediated signalling pathway, which is connected to the removal of ROS, may inadvertently protect cells from inflammatory damage through antioxidant activation (Thimmulappa., 2006 and Khor *et al.,* 2008).

Nrf2 coordinates the basal and inducible expression of xenobiotic metabolism- related enzymes (such as antioxidant and phase II detoxification enzymes) to adapt to various oxidative stress (Bryan *et al.,* 2013). The inhibitory binding protein Kelchlike ECH- associated protein 1 closely controls the stability and cellular distribution of Nrf2 (Keap1) (Kansanen *et al.,* 2013). Due to Keap's control, Nrf2 builds up in the nucleus where it dimerizes with tiny Maf proteins and binds to the ARE cis-regulatory regions to activate transcriptional expression (Iton *et al.,* 2007).

Houghton *et al.,* (2016) depicts that numerous genes, such as NAD(P)H: quinone dehydrogenase 1 (NQO1) and a few glutathione S-transferases (GSTs), have been identified as downstream targets of Nrf2 (Hayes *et al.,* 2010). According to studies, inflammation caused by lipopolysaccharide (LPS) or dextran sulphate sodium (DSS) results in a more severe outcome in Nrf2 KO mice because they have decreased antioxidant-related enzyme. Numerous dietary substances, particularly those generated from cruciferous vegetables, such as isothiocyanates and 3,3′-diindolylmethane, are known to affect Nrf2 pathways (DIM).

Sulforaphane, one of the isothiocyanates, has been shown to increase antioxidant and phase II drug-metabolizing enzymes in the liver, gut, skin, prostate, and blood lymphocytes after long-term dosing. Therefore, microgreens made from brassicas that contain a large number of these chemicals may have an impact on the Nrf2 pathway and inflammation (Hu *et al.,* 2006; Thimmulappa *et al.,* 2002; Khor *et al.,* 2006; Xu *et al.,* 2005; Nair *et al.,* 2010 and Keum *et al.,* 2009).

Involving crucial Phase I enzymes like CPY1A1, B1, etc., the arylhydrocarbon receptor (AhR) pathway is also recognised as an essential transcriptional activator of the xenobiotic pathways (Chang *et al.,* 2017). The AhR has a crucial function in the regulation of the immune system, according to recently published data in the literature. AhR has been found to have an impact on regulatory (Tregs) and interleukin-17 (IL-17)-producing T helper cell transcriptional programmes (Wheeler *et al.,* 2017; Li *et al.,* 2018).

Additionally, AhR has been demonstrated to take part in the development of IL-27-induced type 1 regulatory T-cells (Tr1 cells), which produce FoxP3- IL-10 (Ronearolo *et al.,* 2006; Pot *et al.,* 2009; Wu *et al.,* 2011). A key factor in the formation of innate lymphoid cells (ILCs) is AhR activation, which also promotes the production of the receptor tyrosine kinase kit. Furthermore, AhR has been demonstrated to control the activity of B cells, dendritic cells, monocytes, and astrocytes, which in turn modulates immune system function more broadly (Stockinger *et al.,* 2014; Villa *et al.,* 2017; Sherr *et al.,* 2013; Vogel *et al.,* 2013; Liao *et al.,* 2017; Aguilera *et al.,* 2013).

According to Busbee *et al.,* (2013), there have been reports of many bioactive substances interacting with the AhR. Quercetin, resveratrol, and indole-3- carbinol (I3C), which are naturally occurring agonists obtained from plant foods, as well as hazardous substances such manufactured polycyclic aromatic hydrocarbons and dioxin-like compounds, are AhR ligands.

Microgreens have the ability to modify AhR-mediated immunity pathways, including the control of T cells and other immune cells, according to compositional studies of these plants. These plants are rich providers of natural AhR ligands including quercetin and I3C. As a result, we suggest that microgreens may have a role in the regulation of pathways associated to inflammation based on the body of current evidence (Marcus *et al.*, 2008).

xi. Prevention of Obesity, Cardiovascular Disease and Type 2 Diabetes Mellitus by Microgreens

Microgreens have high antioxidant content, such as polyphenols, which can lower the risk of developing heart disease. According to several research conducted on animals, microgreens are clearly capable of reducing triglyceride and "bad" LDL cholesterol levels (Huang *et al.*, 2016; Tangney and Rasmussen, 2013).

Obesity, cardiovascular disease (CVD), and type 2 diabetes are important chronic illnesses in the United States and other areas of the world, and they frequently coexist with diets high in calories, fat, and poor in fruits and vegetables (Lordain *et al.*, 2005). The intake of a diet high in fruit and vegetables is frequently advised for the prevention of various illnesses, which is supported by a wealth of literature from both population and experimental research (Hung *et al.*, 2005). A proposed mechanism to explain how dietary- derived bioactives can function is the prevention of chronic inflammation, one of the common risk factors for the onset and progression of various chronic illnesses. Microgreens from red cabbage appeared to stop weight gain caused by a high-fat diet (Huang *et al.*, 2016).

As per the study by Choi *et al.*, (2013) and Berry *et al.*, (2012), this microgreen's effects could be linked to its capacity to lower adipogenesis. It has been suggested that a number of phytochemicals contained in vegetables and microgreens, including I3C and retinoic acid (RA), a metabolite of carotene, can inhibit adipogenesis.

Choi and colleagues discovered that I3C directly inhibits adipocyte development by silencing the silent mating type information regulation 2 homologue 1 (SIRT1). Thermogenesis regulation, mitochondrial fatty acid oxidation, inflammatory cytokine inhibition, and glucose absorption are all affected by SIRT1 activation, which has been demonstrated to promote multiple cellular signalling pathways (Murata *et al.,* 2007; Gerhart *et al.,* 2007; Yeung *et al.,* 2004; Zhang *et al.,* 2007).

According to Berry and colleagues, RA activates nuclear RA receptors (RARs) and peroxisome proliferator activated receptor (PPAR) to protect mice from diet-induced obesity (DIO). Additionally, it has been demonstrated that a number of natural compounds may both prevent and trigger apoptosis in pre-adipocytes (Rayalan *et al.,* 2008).

For instance, one of the most prevalent flavonoids found in vegetables, quercetin, decreased the potential of the mitochondrial membrane, downregulated Bcl-2 and poly(ADP-ribose) polymerase (PARP), and activated caspase 3, Bax, and Bak in 3T3-L1 pre-adipocytes to cause apoptosis (Hsu *et al.,* 2006).

Additionally, it has been found that a number of other flavonoids, including naringenin, rutin, hesperidin, resveratrol, naringin, and genistein, similarly suppress theproliferation of pre-adipocytes (Kim *et al.,* 2006; Harmon *et al.,* 2001).

According to Frostega (2013), therefore, microgreens may regulate adipogenesis and lipid metabolisms, protecting against obesity and obesity-related co-morbidities including diabetes and cardiovascular disease. One of the primary CVD risk factors is atherosclerosis.

The major focus of preventative and therapeutic approaches has been on modifying the genesis, development, and progression of atherosclerosis (Koh *et al.,* 2010). The formation of atherosclerotic plaque seems to be significantly influenced by the liver's metabolism of cholesterol and the export of cholesterol from macrophages (Oshashi *et al.,* 2005).

Numerous polyphenolic substances, such as flavonoids, have been shown to influence cholesterol/lipid metabolisms by upregulating LXR and ABCG1 PPAR and decreasing the rate-limiting enzyme HMG-CoA reductase, which controls cholesterol production (Li *et al.*, 2009).

Huang *et al.*, (2016) reported that the combined impact of these modifications would lessen the liver's production of cholesterol, increase the release of cholesterol from macrophages, and prevent the onset of atherosclerosis and its likely progression to CVD. Results from prior study point to the possibility that microgreens may reduce circulating LDL while also regulating fatty acid metabolisms. This in vivo animal investigation with microgreens of known chemical compositions showed that dietary microgreens may be able to modulate atherosclerosis.

Obesity and type 2 diabetes are linked to one another. 105 Family history, lifestyle, age, and obesity are type 2 diabetes risk factors (Olokoba *et al.*, 2005). Since studies of the adult population have showed that weight gain considerably raised the risk of type 2 diabetes, obesity appears to be the most crucial of these variables (Wannamethee *et al.*, 2009).

The onset of insulin resistance and obesity appears to be related to inflammation via macrophage release of TNF- and IL-6 (Chen *et al.*, 2015). As a result, the control of inflammation by microgreens may offer protection against insulin resistance. Additionally, it has been found that a variety of organic substances, including flavonoids, can improve insulin sensitivity by activating PPARs (Lee *et al.*, 2006).

The PPARs are recognised as regulators of adipogenesis, glucose uptake, and lipid metabolisms (Monsalve *et al.*, 2013). Lipid breakdown and glucose uptake would both increase as a result of PPAR activation in the metabolic process. Microgreens frequently contain a lot of flavonoids, which may work with PPARs to increase insulin sensitivity and prevent type 2 diabetes. In conclusion, eating microgreens may improve health by reducing the activity of inflammatory pathways linked to the onset and progression of obesity, cardiovascular disease, and type 2 diabetes (Ferre *et al.*, 2004).

xii. Prevention of Cancer by Microgreens

In the US, cancer is the second most common cause of death (CDCP, 2017). In contrast to other diseases, the cause as well as a cure are yet unknown. Thus, cancer prevention becomes a crucial component of the treatment of the illness. According toestimates, a diet high in fruits and vegetables and low in fat and calories can prevent one- third of all malignancies (Donaldson, 2004).

Numerous bioactives generated from food have been postulated to have protective benefits against a variety of malignancies, including the major cancers like breast, prostate, and colon cancer, while the underlying processes remain unknown (Liu., 2004). Again, inflammation may be a key factor in the development of cancer (Gonda *et al.,* 2009).

The aforementioned pathways are implicated in inflammation; moreover, Keap1/Nrf2, AhR, and NF-B are all involved in the development of cancer (Sporn *et al.,* 2012; Murray *et al.,* 2014) and are influenced by microgreens' dietary components. Microgreens may be able to defend against or prevent cancer by acting through inflammatory pathways. Several studies have shown that dietary components like I3C and DIM can stimulate the enzymes responsible for xenobiotic metabolism (Dashwood *et al.,* 2008; Renwick *et al.*, 2009).

Cells will be able to better protect against and eliminate carcinogens if they have the ability to activate xenobiotic metabolisms (for example, AhR and Nrf2 pathways) (Bryan *et al.,* 2013). Microgreens are a great source of indoles and other xenobiotic metabolism- inducing compounds, especially those made from brassica vegetables (Bradfield *et al.,* 2007).

Therefore, a proposed method through which microgreens prevent cancer is the activation of Phase I, II xenobiotic metabolising enzymes. It's also possible that the microgreens can offer defence against hormone-dependent malignancies like breast and prostate cancer by regulating sex steroid hormone-mediated pathways. Indoles and flavonoids, which are obtained from food, have been shown in our work and the work of numerous other groups to regulate or inhibit the pathways mediated by the oestrogen and androgen receptors (Galluzzo *et al.*, 2006).

Renwick *et al.,* (2009) shows that I3C and DIM have been shown to have anti-prostate cancer properties in a prior study of ours (Wang *et al.,* 2012). Physiological amounts of these two substances in that investigation and discovered that DIM and I3C's anti-cancer actions are most likely caused by their impacts on hormone-dependent and xenobiotic metabolism pathways. This study also revealed mechanistic distinctions between DIM and I3C. Xenobiotic metabolic enzymes are both induced by DIM in an AhR-dependent manner.

In the case of I3C, I3Cs only activate (CYP1A1) enzyme in an AhR-dependent manner. The similarities between I3C and DIM suggest that they may act more effectively at the early stages of prostate carcinogenesis, most likely through a combination of effects on steroid hormones and/or the pathway for xenobiotic metabolism. This is true even though I3C and DIM showed mechanistic differences. Meng and others demonstrated that I3C had breast cancer preventive benefits in addition to our earlier studies (Meng *et al.,* 2000).

Meng *et al.,* (2000) presented that, in MCF-7 breast cancer cells, the author discovered that I3C dramatically suppressed the 17-estradiol stimulated oestrogen receptor alpha (ER-) signalling in a dose-dependent manner. Additionally, I3C elevated the tumour suppressor gene breast cancer 1 while downregulating the expression of the oestrogen responsive genes trefoil factor 1 (TFF1) and cathepsin-D. (BRCA1). Thus, microgreens may control the development of breast and prostate cancer by regulating or inhibiting sex-steroid hormone-dependent processes.

Although the intricate web of pathways and how they interact with dietary bioactives to modulate carcinogenesis are yet unknown, there are a number of possible cancer- preventive pathways that microgreens could influence. These include the start, development, and advancement of malignancies as well as the control of inflammation and xenobiotic metabolisms. Overall, microgreens could offer protection against a number of malignancies (Liu *et al.,* 2004).

xiii. Microgreens and Modulation of the Gut Microbiome

The gut microbiome, the interface between the host and the environment, is now thought to be one of the major components regulating host health and the onset of diseases (Clemente *et al.,* 2012). Finding ways to manipulate the gut microbiota represents a promising preventive strategy. In recent years, a critical role for the gut microbiome in development of chronic diseases, intestinal health, and cancers has emerged (Zhao *et al.,* 2013; Owyang *et al.,* 2014; Schwabe *et al.,* 2013).

David *et al.,* (2014) opines that using bioinformatics methods, Ni *et al*. revealed that >400 chemicals included in a plant-based diet are connected to 609 microbial targets in the gut. Diet has a crucial role in modulating the microbiome, and changes may be fast.

Among the substances found in the research include flavonoids including kaempferol, quercetin, and apigenin. Additionally, quercetin, catechin, and puerarin were shown to have actions that regulated the gut flora, according to Huang and others (Huang *et al.,* 2016).

The study uncovered a number of chemicals, including flavonoids like kaempferol, quercetin, and apigenin. Huang *et al.,* 2016 also found evidence that quercetin, catechin, andpuerarin had effects that controlled the gut flora.

According to Tzounis *et al.,* 2011 consuming a lot of flavonoids generated from cocoa boosts the population of lactobacilli and bifido bacteria while decreasing plasma triacylglycerol levels. The gut microbiota can also convert phytochemicals into compounds with bioactivity, such as anti-inflammatory properties (Pray *et al.,* 2013).

xiv. Microgreens and Regulation of Merging Biological Pathways: MRNA, DNA Methylation and Histone Modification

Gene control has changed from being reliant on transcriptional factors to being based on epigenetic processes such chromatin methylation, histone modification, and miRNA regulation (Jaevisch *et al.,* 2003). The literature has several reviews of these molecular processes and their effects on human health (Guo *et al.,* 2015; Russo *et al.,* 2017; Thakur *et al.,* 2014).

According to Wagnet *et al.,* (2013), more significantly, it has been demonstrated that bioactives obtained from food affect these pathways both in vitro and in vivo. Sulforaphane, phenethyl isothiocyanate (PEITC), I3C, and its acid-dimerized derivative are chemicals produced from brassica vegetables that have been shown to influence promoter methylation, histone methylation, and the control of different miRNA.

Additionally, it was discovered that a number of phytochemicals, including as quercetin, curcumin, resveratrol and lycopene, had an impact on DNA methylation and histone modification (Shankar *et al.,* 2013).

Intriguingly, food-derived bioactives seemed to alter the Keap1/Nrf 2 pathway, which controls immunological as well as xenobiotic metabolisms, through epigenetic pathways. Curcumin, tocopherols, sulforaphane, (Jones *et al.,* 2002; Esteller *et al.,* 2000) and DIM (Krouski *et al.,* 2014) are examples of diet-derived bioactives that have been shown to regulate DNA methylation and/or histone modification and restore Nrf2 expression. These outcomes seemed to be related to prostate cancer defence (Yu *et al.,* 2010).

Singh *et al.,* (2006) depicts that therefore, microgreens rich in these bioactive phytochemicals (such as flavonoids, indoles, and isothicyanates) may control DNA methylation, histone modification, inflammation, and oxidative stress, as well as the prevention of many chronic illnesses, including cancer.

xv. Future Perspective of these Microgreens

For microgreens to become an important gardening product, be more fully integrated into the global food chain, and have their health benefits assessed and shared, market integrity must be recognised. Customers' food preferences and tastes have a significant role in their purchasing decisions (Drewnowski & Gomez-Carneros, 2000), therefore offering more details on the products' nutritional characteristics might encourage more health- conscious consumers to make purchases (Asioli *et al.*, 2017).

Guest *et al.*, (2016) highlighted that the majority of microgreen research is conducted at a relatively low level, is restricted to a small group of researchers, and has a narrow focus. There is still more of a vast region to be explored. Additionally, while some microgreen types have undergone research and analysis, many of them have not yet been made available for sale. The impact of sunlight on the growth and nutrition of microgreens has been well studied, however the impact of low night time temperatures on plant growth, nutritional value, and food safety of microgreens has not been examined.

Although preserving the quality and safety of microgreens is still in its infancy, prevention and treatment strategies should be developed since they are advantageous. Although post-harvest light treatments have been shown to stimulate the synthesis of bioactive components, they have not been well studied to be used to a wide variety of microgreens. It is a topic of discussion if phytonutrient substances might provide intrinsic defence against problems with quality and wellness (Bull *et al.,* 2008).

John *et al.*, (2007) reported that it turns out that microgreens are more than simply a nutritious snack or a useful garnish for soups and salads. These tiny seedlings are collected and consumed when they are just a few inches tall, and scientific study has recently demonstrated that they are a true superfood loaded with antioxidants and other health-promoting components. In order to determine the nutritional information for these young edible seedlings harvested at the cotyledon leaf stage, Heal with Food.org combed through recently published scientific research as well as some older studies.

To maintain the quality and lengthen the shelf life of microgreens, a variety of post- cultivation therapies have been identified. Methods for washing and drying microgreens should be more concentrated on the development of ready-to-eat microgreen products. It is crucial to conduct ongoing research to guarantee the safety and quality of this new contribution to healthy diets so that the food industry may find solutions to some of the issues that have presented difficulties for fully grown veggies (Carter *et al.*, 2010).

The study findings by Mir *et al.,* (2017) are important for both the food and gardening industries since they advise consumers to locate a variety of microgreens that are safe to eat. Significantly, the results of the study's overall design indicate that consumer education regarding microgreens, a flexible factor influencing consumers' desire to purchase them, would be necessary to ensure that knowledge of them is not a limiting factor.

The cost, freshness, and growth schedule of the microgreens should all be considered as additional crucial elements. There is proof that they can be produced sustainably with little impact on the environment (for instance, reduced water use, food waste, and food transportation) (Weber, 2017). Microgreens, which can be cultivated year-round in most indoor spaces, especially in well-managed ones, can encourage population increase, urbanisation, and climate change while also increasing the availability of very nutritious vegetable plants all year long (Benke and Tomkins, 2017; Choe *et al.,* 2018; Mir *et al.,* 2017; Weber,2017).

Due to their high nutritional value and potential ease of incorporation into dishes, microgreens will likely encourage the consumption of fresh vegetables, micronutrient competence, and increased bioactive compound consumption for the promotion of human wellness and health. They will also likely have specific health and wellness benefits as useful foods, such as lowered risk of cardiovascular and metabolic disease (Huang *et al.,* 2016; Johnson, Litwin, and Seals, 2019).

xvi. Microgreens as Space Food

According to Benke *et al.,* (2017), as food and food packaging now represent a substantial load on space mission consumables, the future of space missions and extended human stay in space demands the capacity to provide sufficient nutritional intake for space passengers with minimum resupply from the Earth. This is crucial for ensuring that space travellers maintain an ideal nutritional status and for reducing the stress-related side effects of long-duration space travel, such as weight loss, haematological changes, protein oxidation, increased muscle, proteolysis, impairment of eye health, and alterations in the central nervous system.

These consequences are also connected to the crew members' emotional instability, mental stress, and despair. Future space missions must continue to prioritise the production of bioactive, especially carotenoid-rich vegetables as part of their Space Life Support Systems (SSLSs). Microgreens have a short life cycle, a higher nutritional content than full- grown kinds, and can be produced in small, enclosed spaces, making them a possible food source for astronauts on long-term missions. Microgreens are designed to produce food, renew the air by eliminating CO2 and creating O2, and recycle water through transpiration in bio-regenerative closed systems. They are perfect for space flight circumstances since the crew may pick them themselves, guaranteeing their excellent quality and freshness (Shilpa *et al.,* 2020).

2.3. Role of Green Leafy Vegetables in the Management of Common Diseases and Disorders

According to the report by Liu *et al.,* (2004), a diet heavy in fruits and vegetables and low in calories, fat, and also calories can help prevent one-third of all cancerous cells. Numerous bioactive generated from food have been shown to have anti-cancer properties, including those against important cancer cells including breast, prostate, and colon cancer. However, the mechanisms are yet unknown. The development of cancer can also be significantly influenced by swelling. The importance of the digestive tract microbiome in the development of chronic illnesses, digestion health and wellbeing, as well as cancer cells, hasrecently come to light.

According to Guest and Grant (2016), diets high in polyphenols, anantioxidant, can reduce the risk of developing memory-related diseases like Alzheimer. Consuming fruits and vegetables high in polyphenols and antioxidant, may reduce the risk of developing many cancers (Zhou *et al.,* 2016).

Green leafy vegetables (GLV) and fruits are discovered to be extremely underrepresented in the Indian diet, which suggests that many people there suffer from important micronutrient disorders such anemia and vitamin A insufficiency. According to a UNICEF, 2012 study, India has a food security problem that contributes to the 40% underweight rate among pre-schoolers. Numerous studies have shown that the majority of the world's population consumes less than is advised in order to achieve their nutritional needs.

Increased consumption of GLV and vegetables has been linked to a lower risk of cancer, cardiovascular disease (CVD), cataract, macular degeneration, and other age-related disorders, according to published research. Recent research has demonstrated that consuming GLV helps to maintain mental clarity and reduces neurological problems and other diseases linked to nutrition (FASEB, 2015). A new necessity to find a solution has emerged (Lutz *et al.,* 2010), and researchers should concentrate their attention and efforts ondeveloping creative solutions that can assist solve the issue and guarantee food security.

Most people utilise these crisp, somewhat bitter, nutrient-dense greens to produce raw salads (Shukla *et al.,* 2016). Plants are a major source of a variety of bioactive substances known as phytochemicals, which are thought to be essential for optimal health (Dias, 2012). As a result, phytochemicals can be generally categorised as food ingredients (e.g., essential fatty acids, proteins, vitamins, minerals and phenolic compounds).Underutilized foods are becoming more and more important in today's world as a way to boost food supply per person (Edelman *et al.,* 2016 and Gopalan *et al.,* 2000).

NIN (2013) reported that green leafy vegetables have a significant position among food crops since they offer sufficient level of many vitamins and minerals for people. They are a good source of minerals including calcium, iron, and phosphorus as well as vitamins like beta-carotene, ascorbic acid, riboflavin, and folic acid.

There are several underused greens in nature with great nutritional content that can feed the world's expanding population. Green leafy vegetables are essential for human nourishment, particularly in impoverished nations. India has a wide range of green vegetable species because of its diverse natural environments, changing climes, and changing seasons. There are many leaves ingested, including leaves from annual plants, aquatic plants, and perennial trees (Da Silva *et al.*, 2017).

Guil *et al.*, 2016 highlighted that spinach (*Spinacia oleracea*), amaranth (*Amaranthus gangeticus*), fenugreek (*Trigonella foenum graecum*), drumstick (*Moringa oleifera*), cabbage (*Brassica oleracea var. capitata*), bathua (*Chenopodium album*), etc. are some of the green vegetables that are frequently eaten. These greens are affordable, produce a lot, are consumed locally, and are frequently accessible.

Due of their flavour, several greens, such as basil (*Ocinum basilicum*), bay leaf (*Laurus nobilis*), mint (*Mentha spicata*), curry leaf (*Murraya koenigii*), and coriander leaves (*Coriandrum sativum*), are also employed as leafy spices. Vegetables are typically referred to as "protective foods" in the human diet owing to the variety of health advantages they provide due to their high vitamin, essential fatty acid, mineral, amino acid, and dietary fibre content, as well as other necessary bioactive chemicals (Iheshiulo *et al.*, 2017).

Young people are becoming increasingly unaware of the availability of these nutrient-dense food plants (Odhav *et al.*, 2007). They are essential protective foods that are beneficial for maintaining health and preventing a number of disorders (Fresco *et al.*, 2004). They are important sources of nutrients, particularly in rural regions where they significantly contribute to the minerals, vitamins, fibres, proteins, and other nutrients that are typically in limited supply in daily meals (Asaolu *et al.*, 2012 and DGA, 2015).

Nath *et al*., (2004) presented that they also bring diversity to the menu. Leafy vegetables are advised for weight control since they have low energy densities. Vitamins are critical for maintaining good health, and vitamin C is a crucial micronutrient needed for the body's regular metabolic processes.

Green leafy vegetables include a variety of minerals that are essential for development, metabolism, and other processes, including iron (Fe), calcium (Ca), phosphorus (P), copper (Cu), zinc (Zn), sodium (Na), and chloride (Cl) (table 1). Iron (Fe), calcium (Ca), potassium (K), sodium (Na), and other elements are the most common ones tobe found in green leafy vegetables (Trumbo *et al.*, 2004).

Otles *et al*., (2014) depicts that dark lettuces are high in vitamins A, C, and K; consistently consuming them can enhance ones vision, bone health, and skin suppleness while promoting healthy bloodclotting. Given its low calorie content and high vitamin content, spinach is one of the most nutrient-dense foods on the market. It is also one of the most delicious foods. It is loaded with foliate, vitamins A and C, and other nutrients.

Cooked spinach provides greater nutrients than raw spinach, but it is also delicious in salads when eaten raw since heat lowers the green's oxalate level, releasing its dietary calcium. These include phenolic compounds and antioxidant-rich secondary plant metabolites that are beneficial to health (Saeed *et al.*, 2012).

A minimum of 400 grams of fruit and vegetables should be consumed daily, excluding potatoes and other starchy tubers, according to a 2003 study from the WHO/FAO. This recommendation also applies to the prevention and treatment of a number of micronutrient deficiencies. Based on a daily calorie consumption of 2000, the American Dietary Guidelines recommend five servings of vegetables (HHS/USDA, 2015).

Gopalan *et al.*, (2004) depicts that fresh green vegetables are also excellent providers of folic acid, which is necessary for red blood cell development and proliferation. With more than 20% of the RDA for each of these vitamins in each serving, cabbage is a fantastic source of vitamin C and vitamin K. In addition to being a strong source of dietary fibre, vitamin B6, and folate, 100 grams of cabbage also contain little amounts of all other nutrients. Arugula or tara mira (*Eruca vesicaria*), romaine lettuce (*Lactuca sativa L. var. longifolia*), and butterhead lettuce are among the dark green lettuce varieties (*Lactuca sativa var. capitata*).

There is a vast and expanding need for a more sustainable, accessible, and nutrient- rich food supply as a result of the worldwide urban population expansion. Both the public and private sectors are interested in urban farming, particularly controlled environment agriculture (such as vertical farms, greenhouses, hydroponics, aquaponics, etc.) (Benke *et al.,* 2017).

Yadav *et al.,* 2019 presented that crops are cultivated in a controlled environment where climate, lighting, and irrigation can all be managed, improved, and even automated with the use of data analytics and machine learning. Additionally, urban residents may find this indoor farming to be more accessible and ecologically beneficial (e.g., less water usage and soil depletion). Despite the claims, controlled environment agriculture is still in its infancy and only applies to a small number of agricultural products today.

2.4. Importance of being Healthy

According to Gloria *et al*., (2021), health is the dynamic balance of physical, mental, social, and existential well-being in adapting to conditions of life and the environment. In more practical terms, health may be defined as the ability to respond to all types of environmental situations with the optimal emotional, cognitive, and behavioral reactions while avoiding thosethat is unwanted.

A healthy organism is able to develop a defensive reaction in the face of physiological stress, lowering the risk of injury and restoring a (adapted) equilibrium. The harm (or "allostatic load") persists if this physiological coping mechanism fails, which might eventually lead to sickness (McEwen, 2003).

Thus, whereas fitness refers to the capacity to satisfy the demands of a physical task, health is a condition of whole mental, bodily, and social wellbeing. A person who is healthy and fit has more energy, stamina, and self-esteem and is better equipped to study. A balanced diet and regular exercise can undoubtedly aid in maintaining good health (WHO., 2009).

Mohd *et al*., (2017) depicts that maintaining the necessary energy level to succeed in life requires good mental and physical health. A person who is fit and healthy may live life to the maximum potential without experiencing any significant physical or medical problems. Being healthy encompasses more than just a person's physical well-being; it also refers to their mental stability or sense of inner peace. Living life to the fullest without being physically or mentally unfit is made possible by good health. One's health declines as a result of an unhealthy lifestyle. For every generation, maintaining physical fitness and health is crucial.

i. Influence of Diet and Lifestyle Changes in health

Sreenivasa (2017) reported that the pillars of excellent health and lowered risk, particularly for non-communicable diseases, are a nutritious diet and a healthy lifestyle. The foundations of a long-term healthy lifestyle include a good diet, regular exercise, and enough sleep. The majority of people living in underdeveloped countries continue to fall short of getting the necessary amount of nutrients each day.

The causes are attributed to low economic resources, a lack of focus on the value of micronutrients, ignorance of health issues, and many more. Because of not following a healthy diet leads to malnutrition. Micronutrient malnutrition (MNM) is common in developing nations and is mostly severe in parts of the Asian and African continents. Pregnant women, nursing mothers, teenage females, and children under the age of five are among the vulnerable populations that are most severely impacted (Anjali, 2015 and Sreenivasa *et al.,* 2018). At the worldwide level, iron insufficiency, vitamin A deficiency, and iodine deficiency are the three major prevalent micronutrient disorders.

According to UNICEF, 2020, stunting affected 149.2 million (22.0 percent) of children under the age of five worldwide in 2020 (SDG Indicator 2.1.1). From 33.1 percent in 2000 to 26.2 percent in 2012 and then to 22.0 percent in 2020, the prevalence of stunting has reduced. Just two regions accounted for approximately seventy percent of the world's stunted children in 2020: Central and Southern Asia (37%) and sub-Saharan Africa (70%).

In 2020, there were 45.4 million (6.7%) wasted children under the age of five. More than half lived in Southern Asia, the region with the highest frequency of wasting (over 14%), while about a quarter resided in sub-Saharan Africa (WHO, 2020).

About 5.7 percent (38.9 million) of children under five had overweight issues in the same year. 5.7 percent in 2020 compared to 5.4 percent in 2000 shows little change on a global scale, while trends are accelerating in some areas and in many contexts (Saha, 2020).

The report by WHO., 2016 highlights that the frequency of adult obesity has increased globally, rising from 11.7% in 2012 to 13.1% in 2016. Between 2012 and 2016, the prevalence of adult obesity increased throughout all sub regions, and they are all now fallingshort of the 2025 World Health Assembly goal to reverse the trend by that year.

In 2015, there were 20.5 million (14.6 percent) low birth weight infants worldwide, or one in every seven live births. Low birth weight new born are more likely to pass away within the first 28 days of life; those who survive are more likely to experience stunted growth, have lower IQs, and later in life are at an increased risk of becoming overweight and obese as well as developing adult-onset chronic conditions, such as diabetes (UNICEF, 2015).

Worldwide, 29.9% of women of reproductive age still suffer from anaemia as of 2019, and there has been no improvement since 2012. There are significant regional variances, with Africa having a frequency that is over three times higher than that of Northern America and Europe (WHO, 2019).

Global Nutrition Report (2018) states that children under the age of five experience increased nutritional issues, with 150.8 million of them being stunted, 50.5 million being wasted, and 38.3 million being overweight. The survey emphasised that malnutrition issues affect women more frequently than they do males. Globally, one third of reproductive-age women are anaemic and obese, compared to a million women who are underweight. Knowing that India, with 46.6 million children, has one third of the world's stunted children, followed by Nigeria (13.9 million) and Pakistan (10.7 million), as well as being responsible for 25.5 million wasted children, is terrible.

In India among adults, 18.6% of women and 16.2% men were underweight, 24% of women and 22.9% of men were obese and 67.1% of adults were anaemic in 2021. In Tamil Nadu, 12.6% of women and 12.1% of men were underweight, 40% of women and 37% of men were obese and 57.4% of adults were anaemic (NFHS, 2021).

The study by IFPRI., (2022) shows that in 2020, children less than 5 years 42,324 were underweight, 9527 of them were obese, 52,676 of them were stunted and 16,009 of them were wasted in Coimbatore, when compared to adults 1,03,992 of them were underweight, 5,15,830 of them were obese and 5,31,574 of women were anaemic in Coimbatore.

India, the second-most populated nation in the world and the seventh-largest in termsof territory, was placed 103rd out of 119 nations in the Global Hunger Index., 2018 (GHI) study. Despite being the second-largest producer of food grains in the world, India still facesmajor health hazards connected to nutrition and food despite having 72 years of independence. According to a 2016 World Health Organization (WHO) study, eating junk food and fast food is a key factor in the promotion of non-communicable diet-related disorders such obesity, underweight, cardiovascular disease, cancer, and diabetes, among others.

Surprisingly, despite decades of worry and exposure, researchers have shown that a significant gap exists between actual and recommended intake of green leafy vegetables and fruits in highly urbanized nations including Australia, Canada, Europe, the UK, and the USA. This disparity is particularly pronounced in developing countries like India (Sreenivasa., 2017). Protein-Energy Malnutrition (PEM), Iodine Deficiency (ID), Vitamin A Deficiency (VAD), and Iron Deficiency Anemia (IDA) are the main nutritional issues in India (NIN, 2012).

According to WHO (2019), an essential component of living a healthy life is having a good diet. Physical activity, when combined with a balanced diet, can assist in achieving and maintaining a healthy weight, lowering chance of developing chronic illnesses like cancer and heartdisease and improving general health.

Foods have been crucial to the development of human culture (Milttonet *et al.*, 2003). Foods provide calories and critical nutrients that are important for human growth, development, and survival (Krehl., 2008). In many cultures, food is utilised to feed people, but it has also served as a method for avoiding and resolving health issues (Pieroni *et al.*, 2006). The modern area of food science and nutrition reflects the growth of humanity, and advancements have been made thanks to the infusion of knowledge from fields like medicine, biology, and biochemistry. Nutrigenomics and nutrigenetics methods are now being applied to develop this field of study (Fenech *et al.*, 2011).

The goal of food and nutrition research has also changed from preventing deficiencies (through vitamins, minerals, etc.) to preventing excesses (such as chronic diseases like obesity etc.). The shifts in this paradigm are the end consequence of several years of science-based work. For instance, findings from community and experimental research typically suggest a health-protective benefit of diets high in foods originating from plants (Pezzoto., 2007). There has been an increase in research into the particular diet– microbiome interactions that promote health as a result of growing interest in how the microbiome affects a person's health (Marchesi *et al.*, 2016).

The report by USDA (2015) shows that foods that have comparable nutritional characteristics or biological categories are grouped together as foods. Foods are often divided into food groups in nutrition guides, with daily serving recommendations of each group for a balanced diet. For instance, the USDA in the United States categorizes food into 5 to 11 types, with the 5 main food groups being grains, vegetables, fruits, meat, fish, eggs, and substitutes, milk, and alternatives, fats, and sugar.

2.5. Culinary Aspects of Microgreens

In the past years microgreens represent a new culinary trend (Mir *et al*., 2016). In the beginning of 80's microgreen were used in the menus of the chefs of San Francisco in California and in the second part of 1990's microgreens were used in the southern part of California (United States Department of Agriculture, 2014).

Microgreens have so been suggested as a novel element in recent years, particularly to garnish various cuisines and beverages. (Gioia, *et al*., 2015, Treadwell *et al.,* 2010, Xiao *et al.,* 2012). While microgreens are becoming more widely available as a new culinary trend and are being served in elite restaurants throughout the globe, in the US they have also begun to appear at some grocery shops like Whole Foods and Mom's. (Brentlinger, 2005).

Customers interest in microgreens has increased, particularly among high-end restaurant chefs who utilize a variety of microgreens as garnishes to improve salads, soups, sandwiches, and other culinary creations. However, because of its intriguing qualities, their application has expanded to include enhancing the diet of a specific segment of demanded customers (Kyriacou *et al*., 2016).

While both microgreens and sprouts are eaten when they are still young, they are not the same (Treadwell *et al*., 2013). Bella *et al* reported that the microgreens can be eaten raw where as the matured greens should be cooked before consumption (Bella *et al*, 2020). Factors that are taken into consideration while choosing microgreen species include form, colour (green, yellow, purple, red, crimson, and multicoloured), texture (juicy, crunchy), and shelf life. (Turner and Buchanan, 2020). Caracciolo *et al*. (2020) tested the sensory qualities of twelve different microgreen species on young adults, they found that the sensory qualities such as aroma, bitterness, astringency, grassy flavour, heat, and sourness had a significant impact on the overall acceptance of the product.

Microgreens are optimal choice to offer superior flavour and aesthetic appearance to any dish (Kou *et al*., 2014). The presence of glucosinolates, a class of bitter chemicals, in Brassicaceae family members including Dijon mustard and China rose radish has reduced market popularity. Furthermore, microgreens with higher total phenolic content have favourable relationships with sweetness, acceptability of flavour, and overall eating quality, suggesting that they may be a useful marker of sensory assessment (Xiao *et al*, 2015, Drewnowski and Carneros, 2000).

Gioia *et al* (2015) opined that there are wide variety of wild edible species that are traditionally utilized in folk cookery that can be used in the microgreen production. That offers variety in shapes, colour, taste and all essential nutrients beneficial for health of consumers. Renna *et al* (2016) reported that microgreen based recipes and the procedure of recipe preparation. Recipes such as savoury pastry basket with mousse of robiola cheese, cucumbers, and micro watercress, Corn flour pie with micro brassica raab and Micro radish and lemon sorbet were highlighted by the author.

From a gastronomic perspective, one feature that sets microgreens apart is the chance to work with species and varieties whose cotyledon leaves and first true leaves exhibit a wide range of forms, hues (green, yellow, red, purple), tastes (sweet, neutral, slightly sour, spicy), and textures (tender, crunchy, juicy) (Pinto *et al*., 2015, Xiao *et al*., 2012).

2.6. Awareness on Microgreens

Microgreens are becoming more popular because of their fascinating organoleptic qualities and significant nutritional value. (Sharma *et al*. 2022). Over the past ten years, there has been a global increase in people's desire to consume fresh, healthful, and functional foods like microgreens and sprouted seeds, particularly during and after the COVID-19 epidemic (Ebert, 2022). Microgreens meet their maximal consumption in a very short amount of time, which makes them a very appealing commodity for manufacturers. (Marchioni, 2021)

Khatoon and Singh conducted a study on awareness, cultivation and consumption practices of microgreens among urban women of varanasi in the year 2022. According to the study 17.59% of the subjects had knowledge on organic food whereas 4.62% had consumed food. The subjects have reported, they have no knowledge on microgreens other than the above two. The reported the baby spinach and baby corn was available in supermarkets and other regular vegetable markets.

Only a 2.77% of respondents had knowledge about microgreens and magazines and social media were their sources of information. The study also revealed that a majority of the respondent (80.55 %), were willing to know about cultivation, consumption, and methods of growing microgreens.

The knowledge and awareness towards mindful eating is essential for healthy living. Michell *et al*. (2020) highlights the importance of educational intervention programs and its positive impacts on customer acceptance. The intervention on microgreens given by Khatoon and Singh in the year 2022 had a very good impact. Initially only 2.4 percent of respondents had knowledge on microgreens. After intervention, about 73.14% subject’s awareness was increased.

Microgreens are an emerging class of produce that have gained increasing popularity (Kyriacou *et al*, 2016, Pinto *et al*, 2015, Xiao *et al*, 2012). Khatoon and Singh, 2022 studied the variations of microgreens used in the diet. The study reported that 43.66% of the subjects included microgreens in raw form as salads, sprouts and garnishing. The cooked form of microgreens was utilized by 9.85% of the subjects as soups and with many recipes. About 46.47% of the subjects reported usage of microgreens in both raw and cooked forms.

Microgreens are gaining more attention from consumers due to their reported health benefits (Kyriacou *et al*., 2016; Sun *et al*., 2013). Eventhough the microgreen market is rising rapidly, it also face so many challenges (Charlebois, 2019, Riggio *et al*., 2019, Wood, 2019). Microgreens are considered as an emerging specialty crop, it is famous in restaurants with fine dining facilities, grocery stores and indoor gardening due to its unique appearance, texture, and flavor (Sanchez and Berghage, 2020, Kyriacou *et al*., 2016).