

**SPECIMEN FORMAT FOR THESES OF MONTH**

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<b>Department</b>	<b>:</b>	<b>Department of Food Service Management and Dietetics</b>
<b>Branch/ Area:</b>	<b>:</b>	<b>Food Service Management and Dietetics</b>
<b>Sub Subject Heading:</b>	<b>:</b>	<b>Microgreen Cultivation</b>
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<b>Title of the thesis</b>	<b>:</b>	<b>“Cultivation and Nutritional Profiling of Selected Varieties of Microgreens and their Acceptability in Incorporated Recipes”</b>
(i) In Roman Script (ii) In roman Script		
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**Abstract within 300 words:**

Microgreens are soft juvenile greens, 2.5–7.6 cm (1– 3 in.) tall. Microgreens are harvested 7–14 days after germination and sold with the stem and attached cotyledons (seed leaves) depending on the species. Despite their small size, these microgreens hold dense concentration of micronutrients and phyto-chemicals. Hence the present study was conducted with the objective to determine the optimal growth conditions for cultivation of microgreens, nutritional profiling, formulation and acceptability of microgreen based recipes. Six types (N=6) of microgreens were selected for the conduct of study. The mustard, radish, chia, sesame, fenugreek and beetroot microgreens were selected. Initially a pilot study was conducted using mustard microgreen, to determine the best growing media, watering method and lighting condition suitable for the growth of microgreens. The cocopeat medium under indirect lighting and top watering method was optimal for growth of microgreens and hence all the selected six microgreens were cultivated using the optimal condition. The growth was monitored and compared in terms of weight, leaf size and stem length on each day (upto 7 days). The analyzed micronutrient and phyto-chemical concentration of the microgreens was superior than their mature counter parts (regular greens). The heavy metal content was low and the microgreens were safe for consumption. The shelf life was also determined using different storage containers under different conditions. Recipes (N=80) were formulated using microgreens and sensory evaluated to determine the overall acceptability. The nutritional composition of the recipes was also determined. The Knowledge, Attitude and Practices (KAP) on Microgreens were assessed among the selected subjects (Self Help Groups - Kudumbashree) (N=81) and awareness was created through live training sessions. Apre and post awareness, knowledge assessment was done to determine the impact of awareness. The subjects scored better in the post awareness assessment and it was understood that the awareness was effective and a positive impact was noticed. Hence efforts need to be made to spread the awareness of microgreens among the public to cultivate and consume them. This will provide an economic means to partake adequate nutrients.

**i) Major objectives :**

- To cultivate different varieties of microgreens and study its physiochemical properties and acceptability in the recipes incorporated.
- To study the type of medium and other growing conditions required for the cultivation of the selected microgreens.
- To study the growth of selected varieties of microgreens and to analyze the nutrient content, heavy metals and their shelf life.
- To develop recipes with grown varieties of microgreens and to analyze their sensory characteristics.
- To analyze the Knowledge, Attitude and Practice (KAP) of the selected subjects with respect to microgreens.
- To impart awareness to selected subjects regarding the cultivation techniques and benefits of microgreens.

**ii) Hypothesis:**

**Hypotheses 1**

H 0 = There is no significant association between the micronutrient content and microgreens in comparison to the mature counterparts (regular greens)

H 1 = There is a positive association between the micronutrient content and microgreens in comparison to the mature counterparts (regular greens) Hypotheses 2

H 0 = There is no association between the awareness created and knowledge level of the selected subjects post awareness

H 1 = There is a positive association between the awareness created and knowledge level of the selected subjects post awareness.

### **iii) Methodology :**

The Methodology of the study entitled, “**Cultivation and Nutritional Profiling of Selected Varieties of Microgreens and their Acceptability in Incorporated Recipes**” was carried out in the following phases

### **3.1. Phase I: Growth and Cultivation of Microgreens**

#### **3.1.1 Selection of Samples, Minor Tools and Other Accessories**

The microgreens were selected because they were not consumed by general public. Further, these can be easily grown in a small space and within a short span of time. It contains significantly higher amount of nutrients when compared to normal greens. On top of the above, as the microgreens are grown in a controlled condition with selected medium and light etc., it avoids the presence of heavy metals like lead, arsenic etc. In addition, these microgreens have a peculiar flavor and texture which is completely different from the normal greens making it more acceptable for consumption. Also, these microgreens are very tender and delicate making them a very suitable ingredient to be added in any type of recipes especially salads.

Hence, the selected samples for the study were six types of microgreens seeds Mustard Microgreen (*Brassica juncea*) from Brassica family, Chia Microgreen (*Salvia hispanica*) from Mint family, Fenugreek Microgreen (*Trigonella foenum-graecum*) from the Fabaceae family, Beetroot Microgreen (*Beta vulgaris*) from the Amaranthaceous family, Sesame Microgreen (*Sesamum indicum*) from Pedaliaceae family and Radish Microgreen (*Raphanus sativus*) from Brassicaceae family.

#### **3.1.2. Pilot Study to Select the Best Media, Lighting and Watering Method for Growth of Microgreens**

The pilot study was conducted to analyze the best growing medium, watering method and lighting condition suitable for the conduct of the study. Mustard as a microgreen was selected for the conduct of the pilot study. Based on the pilot study results, the best growing medium, watering methods and lighting were finalized, and further study was carried out.

##### **3.1.2.1. Determination of Best Growing Medium**

The growing medium which was selected to produce microgreens are

- i. Vermicompost and Sand
- ii. Black Soil and Sand
- iii. Coco Peat and Sand

### **i. Growing Medium Composed of Vermicompost and Sand**

The growth of microgreen was analyzed using the vermicompost and sand. The growing medium was prepared by mixing vermicompost and sand in different ratios of 1:1,2:1 and 3:1 respectively. Kitchen waste can be utilized to produce vermicompost.

Using growing medium like kitchen waste is the best way to achieve the sustainable agriculture and an excellent way to avoid chemical fertilizers for the growth of plants (Nath *et al.*, 2009). Vermicompost is a suitable medium as it is an organic approach for the cultivation of microgreens and will have reduced environmental effects. (Sallaku *et al.*, 2009)

### **ii. Growing Medium Comprising of Black Soil and Sand**

The growth of microgreen was analyzed and recorded. According to Duan *et al.*, (2009). The black soil was found to be one of the good sources in providing adequate nutrients to microgreens.

### **iii. Growing Medium Consisting of Coco Peat and Sand**

As a third option, the microgreens were grown using cocopeat and sand as the growing medium. The growing medium was prepared by mixing the cocopeat and sand in different ratios of 1:1,2:1 and 3:1 respectively. According to Awanget *al.*, (2009), cocopeat was found to be the best for the growth of microgreens as it has good pH and water holding/retention capacity.

#### **3.1.2.2. Determination of Best Lighting Condition for Microgreen Growth**

The microgreens were analyzed by subjecting them to various intensities of light.

The microgreens were studied by exposing them to:

- i. Direct Lighting (full exposure to sunlight)
- ii. Indirect Lighting (indirect exposure to sunlight)
- iii. *Light-Emitting Diode*(LED) Lighting

#### **i. Direct Lighting**

Direct lighting is the process of obtaining light directly from the sun for the growth of microgreens. The microgreen containing mud pots were exposed directly to sunlight and the changes were analyzed and recorded.

#### **ii. Indirect Lighting**

Indirect lighting is achieved by preventing the direct exposure to sunlight. The microgreen was subjected to partial sunlight by keeping the mud pots containing microgreens in shade and the changes in its growth were recorded.

### **iii. Light-Emitting Diode (LED) Lighting**

The microgreens were placed in a room with LED bulbs to study the extent of growth of the greens. LED lighting resulted in increased yield of crops (Massa *et al.*, 2008).

#### **3.1.2.3. Determination of Best Watering Method for Microgreen Growth**

Two different watering methods were used to study the growth of microgreens i.e.

- i. Top Watering and
- ii. Bottom Watering

##### **i. Top Watering**

The top watering involves the sprinkling of water on the top portion of the mud pot sown with greens. The micro green was watered on its top layers using the water sprayer.

##### **ii. Bottom Watering**

The bottom watering method involves having stagnant water in contact with the bottom portion of the mud pot containing the media and micro green seeds. For this type of method, the mud pot which has been drilled (hole) in its bottom was used. A base was selected where water was sprayed and the mud pots with holes in the bottom were placed on top of it.

#### **3.1.2.4. Cultivation Process of Microgreens**

Microgreens were grown in mud pots and the growth pattern was further analyzed.

Microgreens are easy to cultivate and harvest in semi-urban and urban environments, and they are served as fresh salads right from the pot in a variety of restaurant chains in India and across the world. Because of their brief lifespan, they require little inputs in terms of fertilizers, nutrients, water, soil, and space (Brazaityte *et al.*, 2015).

Cultivation of microgreens is discussed under different steps:

Step I : Preparation of The Mud Pots

Step II : Sowing of Seeds

Step III: Covering the Mud Pot

Step IV: Watering the Seeds

The detailed process of cultivation is described below.

### **Step I: Preparation of the Mud Pots**

The mud pots used for sowing of the microgreen seeds were of the measurement of Dia. 34 x Ht.18 cm. Wet the mud pot by sprinkling little water and spread the coco peat and sand evenly. Sprinkle some more water over the peat after spreading evenly.

### **Step II: Sowing of Seeds**

Transfer the entire seeds from the packet into a container and scatter the seeds over the mud pot filled with growing media by shaking the container so that it is distributed equally across the surface area of the mud pot. Each packet contained 50 microgreen seeds. These were adequate for the cultivation as one separate pot.

### **Step III: Covering the Mud Pot**

Cover the mud pot with aluminum foil and place the mud pot in a darker area. This was done for 8 hours.

### **Step IV: Watering the Seeds**

Water the seeds twice a day by removing the cover and placing the foil over the mud pot. The water should be sprinkled. Continue this for approximately 6 days, then remove the lid and set the pot in a location where it receives sunlight. On the seventh day the microgreens will be harvested.

### **3.1.3. Cultivation of Selected Microgreens (N=6) in Optimal Growth Medium, Lighting Condition and Watering Method**

Based on the results of pilot study, all the six selected microgreens (Mustard Microgreen, Chia Microgreen, Fenugreek Microgreen, Beetroot Microgreen, Sesame Microgreen, Radish Microgreen) were cultivated in the best growth medium, suitable lighting condition and watering method. After cultivation the growth was analysed in terms of stem length, leaf size and leaf length.

### **3.1.4 Analyzing the Growth of Cultivated Microgreens**

The selected varieties of microgreens were grown in an eco-friendly way. The growth of microgreens was analyzed each day and findings were recorded. They were grown in mud pots in the medium containing coco peat. The microgreens were grown with sufficient water, a water sprayer was used for pouring the water in the correct amount. The harvesting of the microgreens was done using sterilized scissors. The length of the stem and leaf size of the

microgreens were analyzed using the Vernier caliper. The analysis with vernier caliper was found to be adequate for getting the accurate results for the stem length and leaf size (Keutgen, 2021).

### **3.1.5. Comparing the Growth of Selected Microgreens under Different Conditions**

The design of experiments was used to assess the effect of different variables on the growth of microgreens. For each selected microgreen, parameters such as the leaf length, leaf size and stem length were measured to analyse the impact of each variable.

Among the three selected media namely vermicompost, black soil and coco peat, the growth of microgreen in cocopeat was found to be the best and hence coco peat was selected as the preferred media conduct further study on the six selected micro green varieties

Three different lighting conditions were used to grow the microgreen in the pilot study. The lighting methods were direct sun light (direct lighting), indirect lighting (partial sunlight) and LED lighting. Maximum growth of micro green was observed in the indirect lighting method. Hence this method of lighting was chosen for further cultivation.

Among the two types of watering methods, top watering method yielded the best output of microgreens when compared to the bottom watering method. As a result, it was resolved to use top watering method for further study.

## **3.2. Phase II: Analysis of Microgreens and Formulation of Microgreen Based Recipes**

### **3.2.1. Analysis of Micronutrients in Cultivated Microgreens and their Comparison with the Mature Counterparts**

The nutrient content of the fully matured microgreens was analyzed for micronutrients. The vitamins including Vitamin A, Vitamin D, Vitamin E, Vitamin K, Vitamin C, Thiamine, Riboflavin, Niacin, Pantothenic Acid and Folic Acid and micronutrients like Calcium, Phosphorous, Iron, Selenium, Potassium, Sodium, Magnesium, Fluoride, Manganese, Zinc and Copper were analyzed using the AOAC method (Appendix II) for the selected varieties of harvested microgreens. The nutrient content of the fully matured microgreens was analyzed for micronutrients. The vitamin and mineral content of the microgreens are then compared with the mineral and vitamin content of the mature counterparts.

### **3.2.2. Determination of Phytochemical Content in Selected Microgreens**

Microgreens were reported to be the highest source of antioxidants (Ghoora, 2020). Therefore a quantitative estimation of phytochemicals including flavonoids, total antioxidant

activity, chlorophylls, and  $\beta$ -carotenoids contents in the selected microgreens were analyzed. The methods which were used for the estimation of flavonoids was aluminum chloride calorimetric assay. The total antioxidant activity was identified using phosphor-molybdenum method. Chlorophylls and  $\beta$ -carotenoids present in selected microgreens were identified by method of Yang *et al.*, (1998). The antioxidants & phytochemicals such as flavanoids, total antioxidants, total carotenoids and chlorophyll were analyzed (Appendix III).

### **3.2.3. Analysis of Heavy Metals in Selected Microgreens**

Usually the greens cultivated in soil were reported to have various heavy metals (Lenzi *et al.*, 2019). Hence the microgreens which was grown in cocopeat was analyzed for the presence of heavy metals by using AOAC method (Appendix IV).

### **3.2.4. Determination of Shelf Life of Selected Microgreens**

The shelf-life analysis of microgreens was conducted in different storage conditions and in different containers. They were stored in food grade plastic container, glass container, stainless steel container and paper bag. The atmospheric conditions chosen for conducting analysis were normal room temperature and refrigerator temperature.

### **3.2.5. Formulation of Recipes with Cultivated Microgreens**

The cultivated microgreens were used for the preparation of various value-added recipes. The recipes include Ready To Cook, Ready To Eat foods, starters, main dish, side dish, desserts, salads and juices.

- **Starters** The starter is often the first course of a meal, served directly before the main course. The starters prepared using cultivated microgreens were Vibrant spring soup, Green goddess dressing, Green bajji, Green balls, Green rolls, Healthy green momos, Green Semolina veggie rolls, Green dal vada, Green Kabab and Green fritters.
- **Ready-To-Eat (RTE)** foods are a type of food that has been pre-cleaned, precooked, packed, and is ready to consume without any prior preparation or cooking. The prepared Ready To Eat foods with cultivated microgreens were Green bhel puri, Green pea dip, Green fries, Nutria mix, Instant green dip, Green pizza base, Green cookies, Green jam, Green pickle and Green mayonnaise. To improve the micronutrient content of the recipes, here again 50 g of all the selected microgreens were incorporated in the prepared Ready To Eat recipes.

- ***Ready To Cook***

Ready-To-Cook foods are processed or pre-prepared foods that need minimal extra efforts to make. They are also known as convenience foods. The Ready To Cook dishes prepared with microgreens were Green leaves steam cake powder, Soup powder enriched with greens, Green custard powder, Healthy noodles, Instant green payasam mix, Ready To Cook green uppuma mix, Instant sambar mix , Instant rasam powder, Green pancake mix and Soup Mix. As a standard measure 50 g of each of the microgreen were added in all the Ready To Cook recipes to improve the micronutrient content

- ***Main Dish***

Microgreens can also be substantial enough as a main dish with one of the high protein foods such as meat, fish, egg or cheese forms as the base. The main dishes which were prepared using microgreens include Green elaada, Breakfast wraps, Green chappathy, Green biriyani, Green sandwich, Green idiyappam, Green kozhukatta, Green orrotti, Green masala rice and Green Puttu. Only 20 g of three selected varieties of microgreens were added together in each recipe for improving the micronutrient content.

- ***Side Dish***

Side dishes are ought to be small, dainty, and toothsome. They add variety to the menu and diet. The side dishes prepared using microgreens were Green chutney , Green pachadi, Green buttermilk, Green thoran, Green eruchery, Green dal curry, Green kulambu , Greens gram curry, Go green bowls and Green mezhukuperatty. Similarly three micro greens weighing 20 g each were added in each side dish recipe to improve the micronutrient content.

- ***Salads***

Salads can be defined as a dish of raw, cold, or warm cooked foods, usually dressed and seasoned, served as an appetizer, side dish or main course. Salads are usually fresh and have stimulating flavor. The salads prepared with microgreens include Sprouts green salad, Nutri salad, Protein green salad (cereals, pulses green mix), Green fruit salad, Fish Green salad, Grilled green veg salad, Chicken green salad, Classic green salad , Mixed green salad and Roasted vegetable salad with green mix. 20 g of three selected varieties of microgreens are added together in each recipe for improving the micronutrient content.

- **Juices**

Juice is a drink made from the extraction or pressing the fruit and vegetables. The juices prepared with microgreens was green lime juice, green cucumber juice, green mojito, green kiwi juice, amla green juice, green mango juice, green passion fruit juice, green apple juice, green freshener juice and green mint juice. Each microgreen weighing 50gm was added to all the juices individually to improve the micronutrient content.

- **Desserts**

Dessert is a course that concludes a meal. The course consists of sweet foods such as confectionaries, ice-creams, biscuits, cookies, cakes, gelatins, puddings, pies, macaroons, sweet soups, fruit salads, custards, etc. The prepared desserts with microgreens were Khulfi, Green fruit yoghurt, Green pudding, Green khoa, Green mix stuffed gulab jamuns, Green Honey cake, Green praline, Nutrient rich macaroons, Green custard and Biscuit cake. A random combination of three microgreens weighing 20 g each were added together in each desserts for improving the micronutrient content.

### **3.2.6. Determination of Nutritive Value and Sensory Evaluation of the Developed Microgreen Based Recipes**

#### **3.2.6.1. Determination of Nutritive Value of Microgreen Based Recipes**

The nutritive value of the microgreen recipes was calculated and compared with the Recommended Dietary Allowances. Nutrients calculated for each meal were summed up and specific nutrients like calories, carbohydrates, protein, fat, fiber, calcium, phosphorous, potassium, iron, zinc, vitamin A, vitamin C and vitamin E per day were calculated. The calculated nutrients were presented along with the recipes (Appendix V).

#### **3.2.6.2. Sensory Evaluation of the developed Microgreen Based Recipes**

Considering the importance of sensory evaluation, recipes were examined by semi-trained panel members. Based on the score obtained during the evaluation, the dishes were graded from most acceptable (highest score) to least acceptable (lowest score). The organoleptic evaluation of the formulated recipes with microgreens was done using 9 point hedonic scale. The 9 points hedonic scale was considered for its reliability, acceptability, and discriminative ability. The test was conducted to evaluate characteristics such as color, taste, appearance, flavor, and overall acceptance. Recipes were presented to each of the panelist.

Each of the panelists tasted the recipes and gave scores from 1 to 9, where 9 indicates the best acceptability and 1 represents the least acceptability.

### **3.3.Phase III: Determination of Knowledge, Attitude and Practices (KAP) on Microgreens and Creating Awareness on Cultivation and Importance of Microgreens among Selected Subjects (Self Help Groups - Kudumbashree)**

#### **3.3.1. Assessment of Pre-Knowledge, Attitude and Practices (KAP) on Microgreens among Selected Subjects (Self Help Groups - Kudumbashree)**

##### **3.3.1.1. Selection of Subjects**

The subjects selected were from the self-help groups situated at Kottayam district, Kerala. Married women were selected for the study. Women of age group between 35-65 were selected.

The sample size was determined using the formula by Vishwakarma., (2017). Based on the formula, the sample size was determined as 100 numbers, hence the same number of subjects were selected for the conduct of the study.

$$\text{Sample Size} = (Z\text{-score})^2 * \text{Std Dev}^2 / (\text{margin of error})$$

The samples were selected using the purposive random sampling method. Judgmental or subjective sampling method is the other term for purposive sampling method, is a form of non-probability sampling. In purposive sampling method, the participants among the population are selected based on the judgment of the researcher itself (Kothari *et al.*, 2019).

##### **3.3.1.2. Assessment of Pre-Knowledge Attitude Practices (KAP) on Microgreens**

The Knowledge Attitude and Practices (KAP) survey is a quantitative method (predefined questions formatted in standardized Interview Schedule) that provides access to quantitative and qualitative information (Appendix VI).

Knowledge on healthy behaviour is considered to be beneficial. Although, it does not guarantee that this behaviour will be followed. The survey's assessment of knowledge assists in identifying areas where information and education activities are to be exerted. Knowledge was assessed using the Interview schedule that contains background information and socio economic status of the subjects. Knowledge regarding importance of microgreens and presence of nutrients in the same, consumption pattern of greens and importance of kitchen garden were assessed from the selected subjects.

Attitude questions on the need of microgreen farming, general attitude towards the microgreen cultivation, attitude that the microgreen seeds are not available for purchase and expensive for cultivation were analyzed.

Practices or behaviours are the observable actions of an individual in response to a stimulus. The questions regarding the practice of microgreen farming in home garden, encouraging the consumption of microgreens in family and the practice of continuing the microgreen farming in future were recorded

Before the assessment, the subjects were oriented about the study and this helped in smooth conduct for collection of data. The majority of the questions were structured as Yes or No questions. The correct answers were awarded 1 point and the wrong answers were not given any score (zero). The total score was fixed to 25. The samples who got more than 10 points were considered as having more knowledge and those having a score of less than 10 were considered to have less awareness.

According to Krueger, (2015), the evaluation can be done better if the investigator fix a score for the pre and post knowledge assessment.

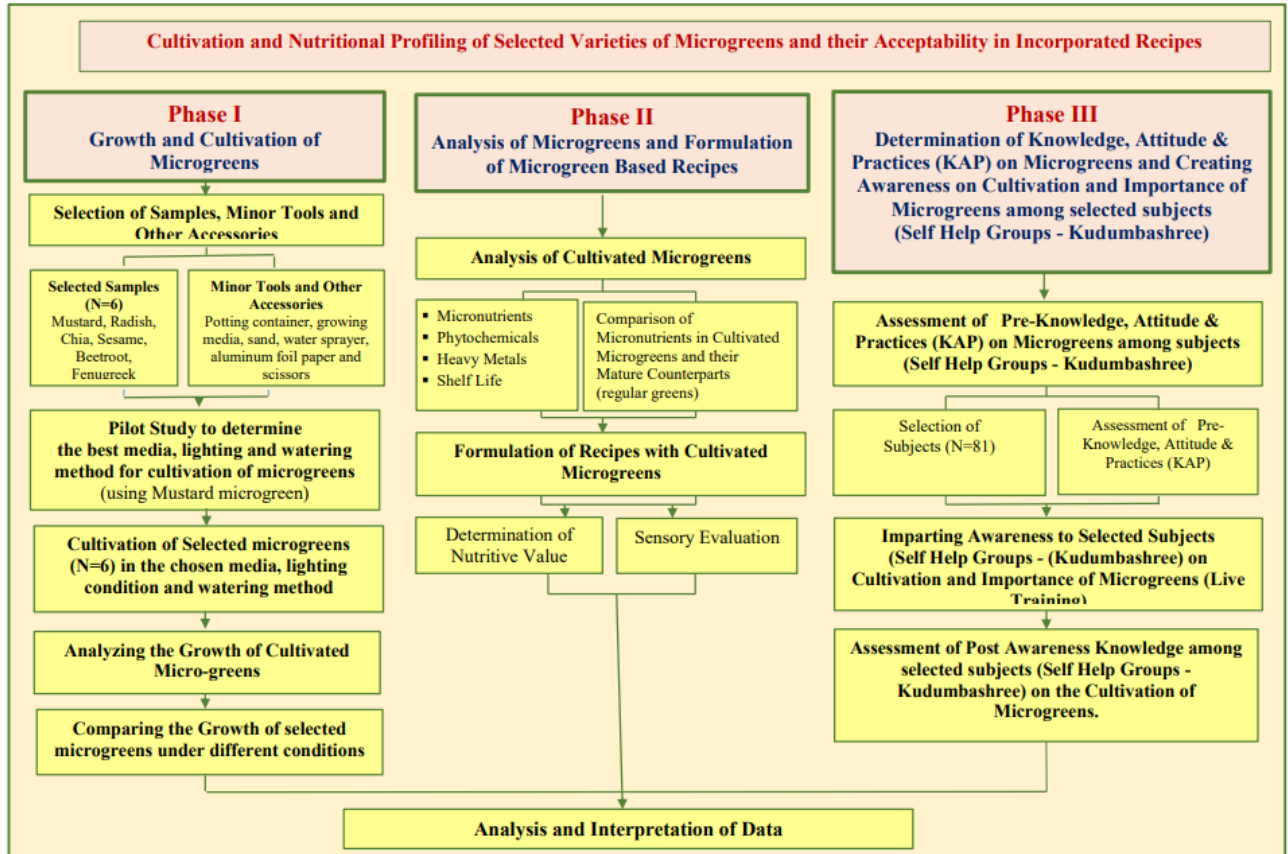
### **3.3.2. Imparting Awareness to Selected Subjects (Self Help Groups Kudumbashree) on Cultivation and Importance of Microgreens**

Alive training session was conducted the selected subjects on the cultivation techniques of microgreens and its importance for self-help groups. The sessions were conducted with the help of the minor tools and the necessary accessories used for the cultivation process of microgreens like mud pots, microgreen seeds, cocopeat and water sprayers.

### **3.3.3. Assessment of Post Awareness Knowledge among Self-Help Groups (Kudumbashree) on the Cultivation of Microgreens**

Before the training session an interview schedule was given to the selected samples for assessing their knowledge on the microgreens. The live training session has helped the homemakers to motivate themselves and do the cultivation process of microgreens in their kitchen garden. This was indeed used for generating information on the cultivation and importance of microgreens among the selected samples. After the live training session, the schedule was given to the same samples to assess their knowledge and feedback on the session. The scoring was done in same method as it was done for the pre awareness session. The pre awareness and post awareness knowledge scores were recorded and analyzed.

Figure 1: Research Design



#### iv) Findings:

The Salient Findings of the Study are Summarized below:

##### Growth and Cultivation of Microgreens / Results of the pilot study:

The pilot study aided to determine the best growth media, lighting condition and watering method suitable for the growth of microgreens. The microgreens exhibited different changes based on the growth media, lighting condition and watering methods. Mustard microgreens was selected for the conduct of pilot study.

##### Determination of Growing Media for Cultivation of Microgreens

- The mustard microgreens grown in the Vermicompost and sand at 1:1 ratio was weak and unsuitable for consumption. At 2:1 ratio Microgreens were not properly growing. At the 4<sup>th</sup> day microgreens appeared to be weak and inappropriate for cultivation. At 3:1 ratio, microgreens tend to shrink at 3<sup>rd</sup> day of cultivation.

- Microgreens grown in the Black soil and sand at 1:1 ratio were found to be having yellow discoloration at 3<sup>rd</sup> day of cultivation. At 2:1 ratio an yellow discoloration was observed at the 4<sup>th</sup> day. At 3:1 ratio the growth was very slow and weak.
- In the cocopeat medium of 1:1 ratio microgreens were weak and unsuitable for further study. In 2:1 ratio, adequate growth was observed in terms of increased leaf size and stem length. The microgreens were found to be yellowish and weak at 3:1 ratio.
- Analyzing the growth of mustard microgreens from day 1 to day 7 in different medias the cocopeat had a very good yield. Therefore, Cocopeat were selected for the further conduct of the study.

### **Analysis of lighting pattern and watering methods used for the cultivation of microgreens**

Microgreens were grown in the cocopeat medium under different conditions. The different conditions were categorized into three treatments based on the lighting such as Direct Sunlight (Treatment I), Indirect Sunlight (Treatment II) and LED Light (Treatment III) and each treatment was categorized into two, in which one set of microgreens was top watered and other bottom watered. Based on the lighting pattern and watering methods visual appearance of the microgreens was observed and noted.

- The microgreens subjected to Direct Sunlight (Direct lighting) and Top Watering were Slightly Bending at the 7<sup>th</sup> day. The Leaves and stems appeared to be thin and weak. In a treatment with Direct Sunlight (Direct lighting) and Bottom Watering, Severe Bending at the 7<sup>th</sup> day was observed. The stem were long and frail.
- On Indirect Sunlight (Partial Lighting) and Bottom Watering treatment, the leaves of microgreens shrank at 6<sup>th</sup> day and the stem started to bend on 7<sup>th</sup> day. The microgreens under Indirect Sunlight (Partial Lighting) along with top Watering had a Perfect stature.
- Smaller leaf size and Slight Bending of leaves at 7<sup>th</sup> day was observed among microgreens treated with LED lighting and Top Watering treatment. In the LED lighting treatment with Bottom Watering, Severe Bending was observed on the 7<sup>th</sup> day and the water started to clog and the stems rotted.

- Hence based on the pilot study it was concluded that cocopeat is the best suitable media, partial/ indirect lighting was found to be the best lighting condition and the top watering was the suitable watering method for the efficient growth of microgreens.
- After determination of the best growing conditions, all the selected six microgreens were cultivated and the growth was analyzed.

### **Analyzing the Growth of Cultivated Microgreens**

- Each microgreen was cultivated and the stem length, leaf size and leaf length were measured for seven days. The growth of each microgreen was compared for its leaf and stem length from day 3,5 and 7.
- The leaf size and stem length of fenugreek microgreens was maximum compared to the other microgreens on day 3 and day 5. On the 7<sup>th</sup> day, the radish microgreen had the largest leaf that was 0.82 inches. And the stem length of fenugreek microgreen was the maximum (1.78 inches) on day 7. In regard with the weight of microgreens at the time of harvest, the mustard microgreen weighed the most that is 28.34 g followed by fenugreek microgreens (27.12 g) and sesame microgreen (24.5 g).The chia microgreen weighed the least, that is 15.02 g.
- The Mean Difference Between Stem Length and leaf size of the Selected Microgreens from Day 1 to Day 7 was analysed using One-Way ANOVA. Significance was observed between the stem length and microgreen on day 1, day 2, day 3, day 4 and day 6. Between the leaf size and microgreen significance was observed on day 1, day 5 and day 6. The growth pattern of the microgreens was analyzed with design of experiments for determination of the impact of different variables on the growth of microgreens.

### **Analysis of the Growing media used for the Cultivation of Microgreens**

- The cocopeat was tested to determine the **nutrient content** of the medium in which the microgreen were grown. Tests were also done to elicit the microbial counts in the growth media.
- The pH value of the medium was 7.2, which depicts that the peat is basic in nature. The average Phosphorus content in the growth media was 12.6-13.01 mg/kg and Potassium content was 4.1-4.31 mg/kg. The growth media contains the total nitrogen content of 4.09 percent. The organic carbon present in cocopeat was 47.4 percent, which is *essential for plant fitness in natural environments*.

- The total bacteria found in peat was maximum (76 CFU/g of sample) on the 7<sup>th</sup> day. The total fungi was high on Day 6 that was 23 CFU /g of sample. The actinomycetes was found to be 7 CFU/g of sample on Day 5 and 7, and on Day 6 the actinomycetes count was 5 CFU/g of sample. The Phosphobacteria was present in more on the 7<sup>th</sup> day with a 41 CFU/g of medium. The amount of Pseudomonas sp. were high (67 CFU/g of the sample) in the 6<sup>th</sup> Day of cultivation. The count of Azotobacter was reported to be high on day 7 with CFU of 27 per gram of sample. The count of Azospirillum and rhizobium was 0 CFU/g of sample.

### **Analysis and Comparison of Vitamin Content in Selected Microgreens with the Mature Counterparts.**

Beet microgreen had the highest Vitamin A (48.8 mg) than its mature counterpart and all other microgreens. The tender shoots had more vitamin A than the mature parts. Chia microgreen and radish microgreen did not contain Vitamin A. Vitamin D was not present in all the selected microgreens. Mustard microgreen had the highest amount of Vitamin E (2.89 mg) than its mature counterpart and all other microgreens. The Chia microgreen had highest amount of Vitamin K, that is 302 mg. The mature counterpart of Chia microgreen had more Vitamin K than other matured microgreens.

Vitamin C a potential antioxidant is present more in Mustard microgreen (89.5 mg). The Vitamin C content of the mature counter parts was low. Sesame microgreen did not contain Vitamin C. Vitamin B1 was high in Fenugreek Microgreens (8.3 mg) than the mature part. Vitamin B2 (4.17 mg) and B3 (5.83 mg) was more in chia microgreen. Radish microgreen did not contain Vitamin B1, B2 and B3. Vitamin B5 was present more in radish microgreen followed by its matured part. The Mustard Microgreen, Beet Microgreen, Chia Microgreen did not contain Vitamin B5. Vitamin B9 was present more in Fenugreek Microgreen (36 mg) followed by Radish microgreen (34.6 mg). On the whole, the young parts had more vitamin content than the mature counter parts.

### **Analysis and Comparison of Mineral Content in Selected Microgreens with the Mature Counterparts**

The tender chia microgreens had the highest amount of calcium (402 mg) and potassium (860 mg). The sesame microgreen had the highest amount of iron (15.0 mg). Mustard microgreen had the highest amount of selenium (71.47 mg) and potassium (694 mg). The radish microgreen did not contain iron, selenium, fluorine, manganese, zinc and copper.

The fluorine content was present only in sesame microgreens, the quantity was less but tender part (0.31 mg) had a higher concentration of fluorine than the mature part (0.20). The Manganese content was high in chia microgreen and copper was high in sesame microgreen.

### **Phytochemical Content in Selected Microgreens**

The chlorophyll a was present in higher concentration in mustard microgreens. Sesame microgreens had the higher concentration of chlorophyll b (0.43 mg),  $\beta$ -carotenoids (89.21 mg) and Flavonoids (465.8 mg). The antioxidant activity was also higher in the sesame microgreens. Hence the sesame microgreen had the highest concentration of phytochemicals than the other selected microgreens.

### **Heavy Metals in Selected Microgreens**

Heavy metals such as lead, cadmium, mercury and arsenic were analysed using AOAC.15.01 method. The results shows that no elements were in detectable level and all the microgreens were found to be safe.

### **Shelf Life of Selected Microgreens**

The characteristics of microgreens stored in food grade plastic container, glass container, stainless steel container and paper bag were analyzed for appearance, color, shape and other characteristics were analyzed visually and physically for three days.

On Day 1, no changes were observed in the microgreens and the leaves were fresh both in the refrigerator and at room temperature.

On Day 2, microgreens stored in paper bag were wilted very much, which made it unsuitable for consumption. Microgreens stored in plastic and glass containers were fresh till Day 3.

### **Formulation of recipes with Cultivated microgreens (n= 80)**

Different courses of microgreen recipes were formulated and prepared. The course includes starters, accompaniments, main course, desserts, salads, juices, ready to eat and ready to cook foods. Ten recipes in each of the above categories were prepared.

### **Sensory Evaluation of the Microgreen based Recipes**

- All prepared recipes were sensory evaluated.
- Among the Ready ToCook products, instant green payasam mix ( $44.3 \pm 0.21$ ) and instant sambar mix ( $44.3 \pm 0.20$ ) scored the highest. The green leaves steam Cake Powder scored the least ( $37.3 \pm 0.24$ ).

- Among the Ready To Eat Products, green cookies were more acceptable and scored the highest ( $44.5 \pm 0.31$ ) and the green bhelpuri scored the least with a mean sensory score of  $38.1 \pm 0.38$ .
- Among the accompaniments, green dal curry and green mezhukuperatty were more acceptable and scored the highest ( $43.2 \pm 0.32$ ), ( $43.2 \pm 0.61$ ) respectively. the green pachadi scored the least with a mean sensory score of  $38.24 \pm 0.20$ .
- Among the main courses, green kozhukatta was highly acceptable with a mean score of  $44.6 \pm 0.31$  and the green chappathi was least acceptable ( $38.2 \pm 0.31$ ).
- Among the starters, green dal vadawas highly acceptable with a mean score of  $44.6 \pm 0.24$ . The green bajji scored the least with a mean sensory score of  $40.6 \pm 0.31$ .
- Among desserts, greenkhoa was highly acceptable with a mean score of  $43.6 \pm 0.49$ . the green fruit yoghurt scored the least with a mean sensory score of  $37.2 \pm 0.44$  and was least acceptable.
- Among the salads, the Protein green salad scored the highest ( $42.3 \pm 0.38$ ) and the Classic green salad scored the least ( $37.1 \pm 0.12$ ).
- The Green Apple Juice scored the highest ( $44.4 \pm 0.50$ ) and Mustard Shot scored the lowest ( $35.5 \pm 0.41$ ). among the juices prepared.

**Background Information of Selected Subjects for Determination of Knowledge, Attitude and Practices (KAP) on Microgreens and Creating Awareness on Cultivation and Importance of Microgreens among Self Help Groups (Kudumbashree) was done.**

**Age and Religion of the selected subjects**

- The majority (48 percent) of the subjects belonged to the age group of 55-65 years, 40 percent of the subjects were at the age group of 45-55 years, and the least (2 percent) of subjects were between 35-45 years.
- In regard with the religion, majority (43 percent) of the subjects were Hindus followed by Christians (32 percent) and Muslims (25 percent).

**Educational Qualification of the Selected Subjects**

- Majority of the subjects had an undergraduate qualification (25 percent).
- Among the selected subjects, 11 percent had minimal qualification of SSLC.
- Another 10 percent had completed the Higher secondary examination /schooling.
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### **Occupation of the Selected Subjects**

- Among the selected subjects 41 percent of were teachers, followed by 22 percent home makers.
- A least percentage of 3 percent were accountants and 4 percent were farmers.

### **Socio-Economic Status of the Selected Subjects**

- Subjects of about 22 percent belonged to the upper class which was the major among other category.
- Subjects at Upper middle and Lower middle class were 20 percent and 18 percent respectively.
- Minimum percentage (3 percent) of the selected subjects belonged to the lower class.
- As the women from lower socio economic status were mostly daily wagers, they were not able to take part in the study and hence the participation number was less.

### **Type of Family of the Selected Subjects**

- Majority of the subjects belonged to nuclear family (93 percent) and none of the subjects belonged to extended family.
- A minimum of 7 percent subjects lived as a joint family.

### **Marital Status of the Selected Subjects**

Majority of the subjects were married (84 percent) and about 12 percent were widows. Only a minimum of 4 percent of the subjects were single/ unmarried.

### **Food Frequency Pattern of the Selected Subjects**

- Cereals, grains, pulses, legumes, vegetables, green leafy vegetables, spices, condiments, nuts and oil seeds were consumed by all the subjects on a daily basis.
- The other food groups such as milk and milk products, roots and tubers, fruits, meat, egg and poultry were also consumed daily by majority of the selected subjects on a daily basis in comparison with other food groups.
- Fruits were consumed more than other foods on a weekly basis.
- Among the selected subjects, about 2.46 percent of the subjects claim they never consume roots, tubers, meat, egg and poultry.

### **Knowledge on Microgreens among Selected Subjects**

- According to the KAP Assessment, 95 percent of the subjects were not aware of microgreen seed, their availability for sales, growth media of microgreens and it is not surprising that they were also not consumers of microgreens.
- Only three percent were aware that microgreens are rich in micronutrients.
- Only two percent of the subjects claimed that they like the taste of microgreens.
- Among the selected subjects 96 percent were not aware about the health benefits of microgreens. None of the selected participants had awareness on shelf life of the microgreens.
- More than 95 percent of the population had no knowledge on the storage and cultivation of microgreens.
- Maximum of the subjects claim it's a plant (33 percent) followed by subjects who claim it as a sprout (32 percent). About 18 percent of the subjects do not know what microgreens are.
- All the population wanted to know more about microgreens and were ready to grow microgreens if proper training is given.
- Most of the subjects (92 percent) claimed that they need a booklet containing all the steps of cultivation that would serve as reference for future.
- Among the selected subjects 31 percent agree that they can put in the required amount of work needed for the production of microgreens.
- And 46 percent of the subjects have strongly agreed that they think, they have the technical ability to produce microgreens in their farm within next five years.

### **Attitude towards Adoption of Microgreen Farming**

- All the selected subjects strongly agree to the statements such as governmental support for microgreen cultivation, local consumers would not be willing to pay high for cultivation and on consultations and advices regarding microgreen farming.
- Majority (91 percent) strongly agrees that microgreen farming is complex.
- Among the selected subjects about 87 percent of the subjects strongly agree that without using chemicals high pest infections may occur.
- Twenty one percent of the subjects strongly agree that information on microgreens are very difficult.

- Majority (83 percent) of the selected subjects strongly agrees to the statement that there is a lack of subsidies and only a 3 percent disagreed.
- Forty four percent of the subjects strongly agreed to the statement that microgreens are healthier.
- All the subjects strongly agree to the statements that cultivation of microgreen seeds and farming tools are expensive and it is also hard to find business buyers.
- It was surprising that 81 percent of the subjects strongly agreed, that obtaining information about the growth of microgreens is difficult, 16 percent agrees and three percent neither agree nor disagree.
- Thirty two percent strongly agreed and least (2 percent) strongly disagreed to the statement producing microgreens within the kitchen garden was very good idea.

#### **Awareness on Kitchen Garden among Selected Subjects (N=81)**

- Greens consumption was predominant among all the selected subject (100 percent).
- Among the selected subjects 61percentdid not have a kitchen garden.
- Regarding the cultivation of green leafy vegetables, 70 percent of the subjects did not cultivate green leafy vegetables and 54 percent knew the importance of green leafy vegetables
- A majority (60 percent) of the subjects agree that farming of vegetables will add to expenses.
- And 43 percent of the subjects had the opinion that large amount of water is lost for cultivation purpose.
- Regarding the use of pesticides or insecticides for the protection of the kitchen garden, 80 percent of the subjects reported that they don't use.
- Most of the subjects (91 percent) confirmed that there is need for cultivating green leafy vegetables.
- Majority of the subjects had no awareness about microgreens. The subjects had nil or very less knowledge on microgreen cultivation, place of purchase and nutrients present in microgreens.
- Social Media being the popular means of awareness these days, 5 percent of the subjects claimed that they got awareness from social media and another 4 percent mentioned their source as journals and 1 percent learnt from magazines.

- Among the Home makers, about 4 percent of them received awareness through facebook and about 1 percent through instagram .
- Minimum of the subjects (1.23 percent) claimed that microgreens are bitter in taste.

### **Consumption Pattern of the Cultivated Microgreens by the Selected Subjects**

- Majority of the subjects (14 percent) had grown ladies finger in the kitchen garden and consumed.
- This is followed by the cultivation and consumption of mint and coriander.
- Fenugreek microgreens was not grown for consumption.

### **Consumption Pattern of Green Leafy Vegetables among Selected Subjects**

- Sixty seven percent of the selected subjects used greens in less than one meal.
- A minimal population of about, 5 percent used greens in two to four meals.
- All the subjects (100 percent) incorporated curry leaf for meal preparation and least (54 percent) used amaranth leaf for meal preparation.
- Coriander chutney was the most prepared green leafy based dish, which was prepared by 92 percent of the subjects.

### **Purchase of Green Leafy Vegetables and Budget Used Per day**

- Fourty three percent of the subjects purchased 250-300 gm of green leafy vegetable for meal preparation per day and least (5 percent) purchased 400-500 gm of green leafy vegetables.
- Twenty four percent of the subjects spend Rs.150-200 for the purchase of green leafy vegetables and 14 percent of the subjects spend the least amount less than Rs.50 for purchasing green leafy vegetables.

### **Pre-and Post-Awareness Knowledge Assessment**

- In the pre awareness assessment, majority of the subjects scored low (5 marks), which is depicted as 25 percent awareness level.
- In the post awareness assessment majority of subjects scored 60 percent awareness level. And most of the subjects had more than fifty percent.
- The intervention programme conducted positively influenced the homemakers regarding the knowledge of microgreens and growing method of microgreens.

- Hence it is understood that the awareness was effective and a positive impact was noticed.

## **Conclusion**

The Microgreens despite their advantages like minimum area required to grow, less time needed to cultivate, highly nutritious, flavourful etc is still not popular among the public due to low awareness levels. On the other side people tend to eat healthy and consume a lot of mature greens (normal green leafy vegetables). Hence more awareness need to be brought to the attention of public on the advantages of microgreens to encourage them convert from regular greens to micro greens.

It is possible even for families living in a small area to cultivate adequate micro greens for their family needs. Further large scale cultivation is also possible. This can be converted into a profession/ entrepreneurial opportunity.

It is established that microgreens are nutrient dense and contain over 40 times more nutrient content compare to matured greens. Further they are rich in antioxidants and phytochemicals which are needed to live a healthy life. Hence spreading awareness and enhancing the consumption of micro greens will lead to a healthier society.

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