METHODOLOGY

The research methodology pertaining to the study on 'Triple Burden of Malnutrition in Young Adult Women (18-21 years) and the Effect of Nutrition Interventions on their Nutritional Status and Nutritional Knowledge' is presented under the following phases.

3.1. **PHASE-I: Incidence of Triple Burden of Malnutrition among Young Adult Women (18-21 years)**

- 3.1.1. Selection of the Study Area
- 3.1.2. Selection and Identification of Subjects with Triple Burden of Malnutrition using the Validated Screening Tools.
- 3.1.3. Formulation of Research Tools to Conduct the Study
- 3.1.4. Analyse the Status of Triple Burden of Malnutrition
- 3.1.5. Ethical consideration and confidentiality

3.2. **PHASE -II: Mapping of subjects for Nutrition Interventions**

- 3.2.1. Conduct of the Survey
- 3.2.2. Assessment of Nutritional Status of the selected subjects
  - 3.2.2.1 Anthropometric Measurements
  - 3.2.2.2 Biochemical Estimation
  - 3.2.2.3 Clinical Examination
  - 3.2.2.4 Dietary Intake

3.3. **PHASE - III: Formulation and Evaluation of Dietary Supplements and Nutrition Education modules for Triple Burden of Malnutrition**

- 3.3.1. Formulation and Evaluation of the Dietary Supplements for Nutrition Intervention
  - 3.3.1.1 Formulation of the Dietary Supplements
  - 3.3.1.2 Sensory Evaluation of the Dietary Supplements
  - 3.3.1.3 Cost Effectiveness of the Dietary Supplements
  - 3.3.1.4 Nutrient Analysis of the Dietary Supplements
  - 3.3.1.5 Microbial Count of the Dietary Supplements
- 3.3.2. Development and Validation of Nutrition Education Modules for Triple Burden of Malnutrition
  - 3.3.2.1 Development and Validation of Nutrition Education Modules

3.3.2.2 Imparting Nutrition Education to the Selected Subjects

3.3.2.3 Diet Counselling to the Selected Subjects about Dietary Intervention

3.3.2.4 Website Development to create awareness about Nutrition and Health to the selected subjects.

3.4. **PHASE -IV: Effect of Nutrition Interventions on Nutritional Status and Nutritional Knowledge of Triple Burden of Malnutrition among the selected subjects**

3.4.1. Effect of Dietary Intervention on Nutritional Status of the selected subjects

3.4.1.1 Anthropometric Measurements

3.4.1.2 Biochemical Estimation

3.4.1.3 Clinical Examination

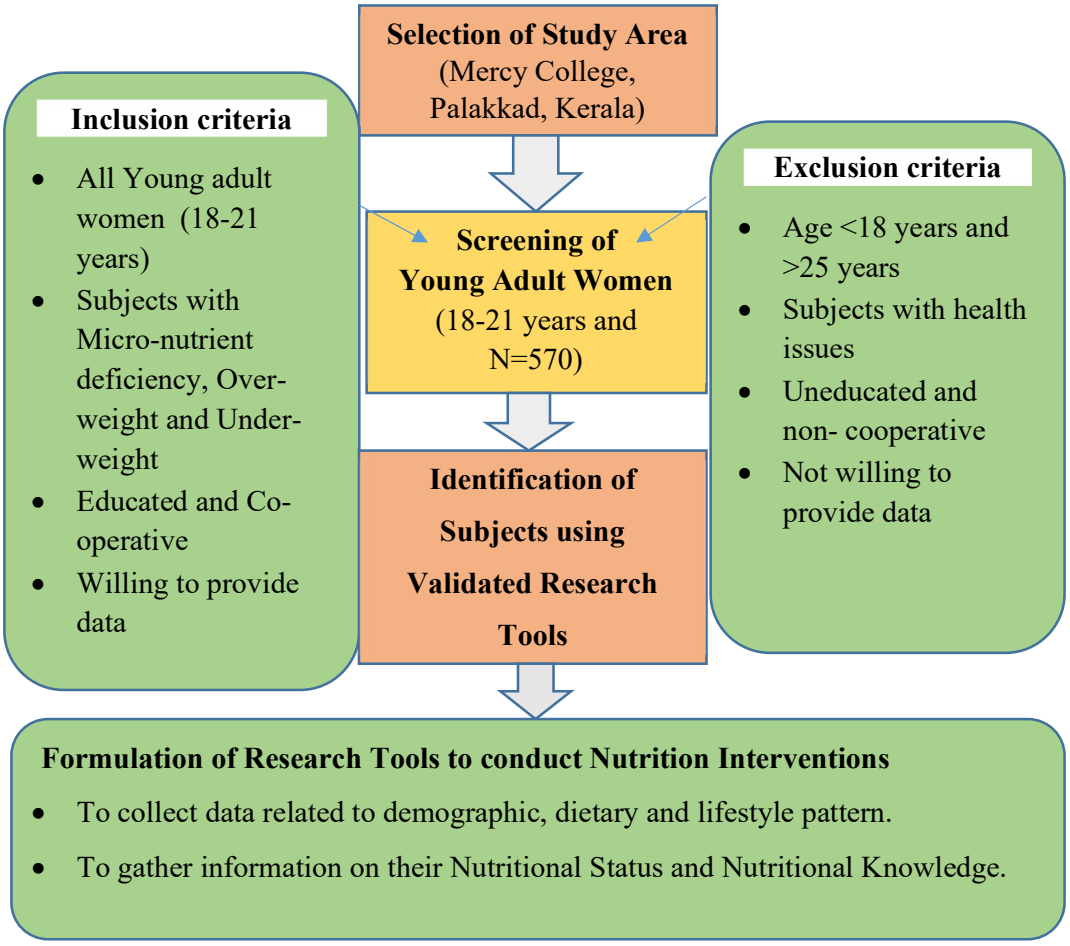
3.4.1.4 Dietary Intake

3.4.2. Effect of Nutrition Education on Nutritional Knowledge of the selected subjects

3.5. **PHASE - V: Statistical Analysis and Interpretation of data**

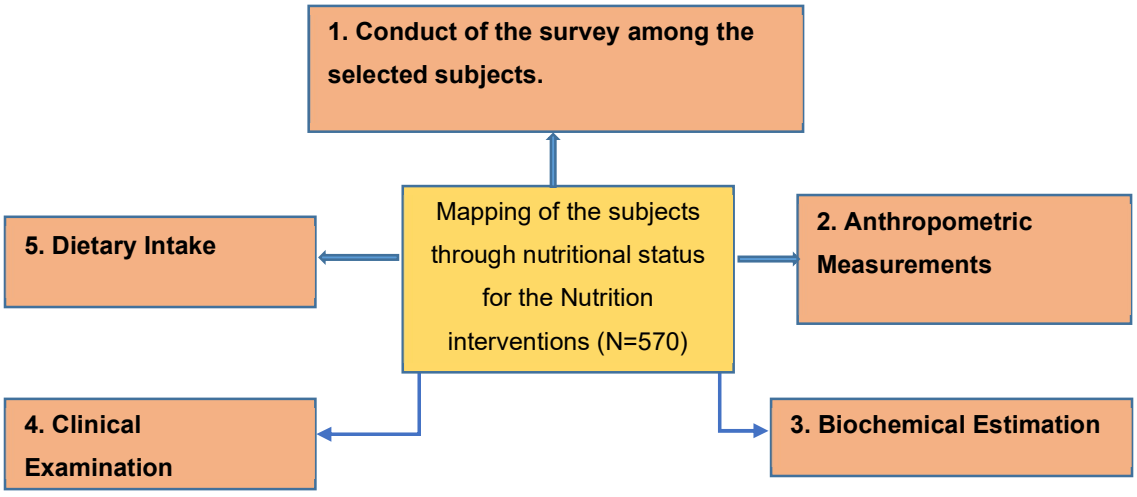
RESEARCH DESIGN

3.1.Phase I



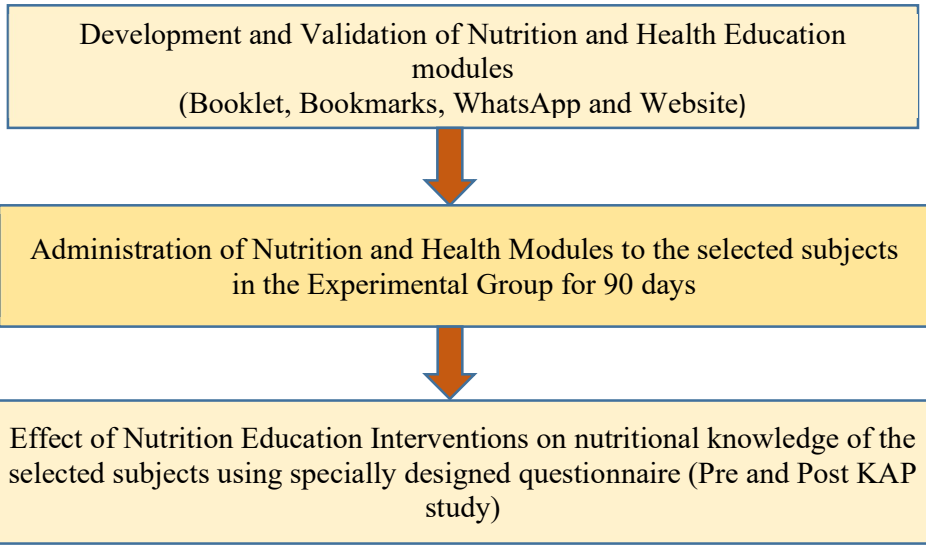
3.2.Phase II

Mapping of Subjects for Nutrition Interventions

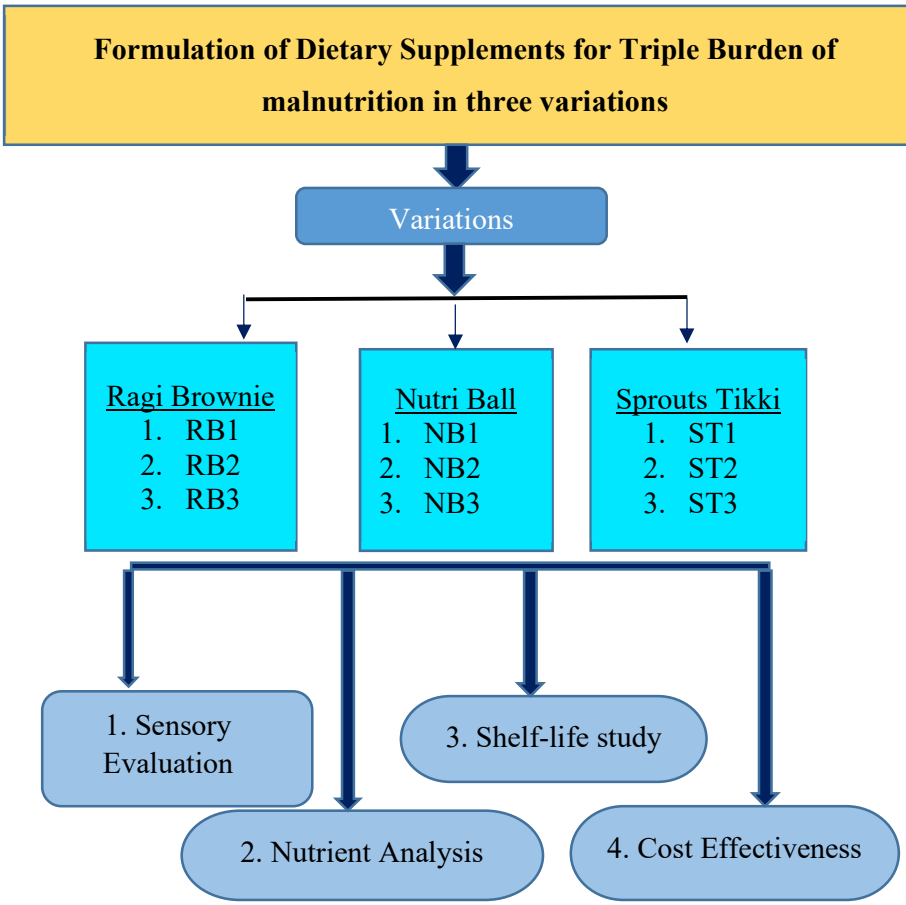


3.3.PHASE III

3.3.1.Development and Validation of Nutrition and Health Education modules for Triple Burden of Malnutrition

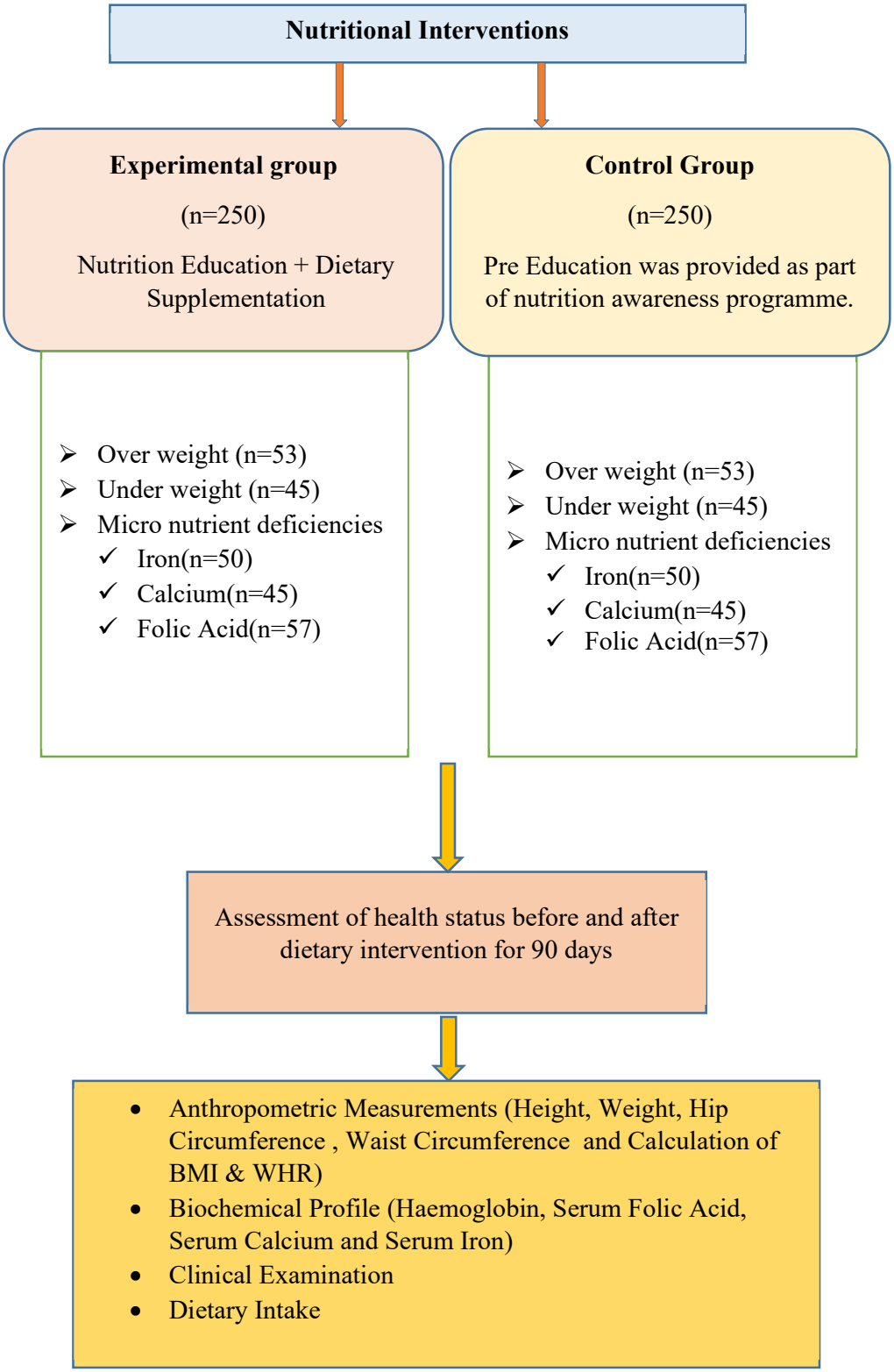


3.3.2.Formulation and Evaluation of the Dietary Supplements



3.4.PHASE IV

Dietary Interventions on Nutritional Status of the Selected Subjects



3.1.PHASE-I: Incidence of Triple Burden of Malnutrition among Young Adult Women (18-21 years)

3.1.1.Selection of the Study Area

The present study was conducted in Mercy College , Palakkad, Kerala. This college was selected for the study on basis of accessibility, availability of young adult women in the age of 18- 21 years as required for the present study, co- operation and co-ordination showcased by the authorities of the Institution. The subjects of the institution were willing to participate in the study with the permission of their institution and their parents.

3.1.2.Selection and Identification of Subjects with Triple Burden of Malnutrition using the Validated Screening Tools.

Observations in NFHS-5 (2020) survey revealed that the micronutrient deficiencies including Iron and other micronutrient deficiencies were still existing among the population especially in young adolescents and adult women with the combination of under nutrition and over nutrition. The prevalence of such malnutrition in the young adult women if unaddressed will have drastic repercussions for the future generations. The present research aims to study the incidence of Triple Burden of Malnutrition among the selected young adult women and provide a sustainable solution in terms of nutrition, health and dietary supplementation and education for the screened subjects for the period of three months. The first year and second year undergraduate girls in the age of 18-21 years were selected for the screening process. The selection of this age group were decided since this group young adult women were susceptible to many health issues and the prevalence of malnutrition in this age group was a striking factor. The nutritional status of the young adult women is vital as they are considered as the future mothers. Any kind of deficiency in the nutritional store of the mother will reflect in the nutritional store of the infant. The sample size calculation was carried out by using Daniel (1999) sample calculation method, using the formula given below.

$$Sample\ size = \frac{Z^2 x\ p(1-p)}{d^2}$$

Where, Z= Level of Confidence

p=Prevalence

d=Margin of Error

By applying this formula, the sample size for the study is 570. The selected subjects will be further divided in to Control group and Experimental group. Table I depicts the inclusion and exclusion criteria considered for the selection of subjects for the current research study.

Table I. Criteria for Selection of the Subjects

Inclusion criteria	Exclusion Criteria
Subjects in the age group of 18-21 years	Women less than 18 years and more than 21 years and pregnant and lactating mothers
Subjects with Micro-nutrient deficiencies, Under-weight and Over-weight	Subjects with Normal weight
Subjects willing to cooperate and involve in the Intervention study.	Subjects consuming any Supplements or Medication and not willing to cooperate in the study.

3.1.3.Formulation of research tools to conduct the study

The present study has used different research tools to carry out the study. The formulation of research tool is the most crucial part of any study. The study has developed questionnaire to collected data regarding demographic profile and nutritional status to screen the risk factors associated with the health issues of the selected subjects. The questionnaire consisted of different questions that helped to analyse the status of socio-economic and dietary pattern, health and nutrition and to find out the education gap to provide the needed knowledge to promote health and nutritional status and to prevent health issues. A booklet and website was developed to impart nutritional knowledge to the selected subjects.

3.1.4. Analyze the status of Triple Burden of Malnutrition

To analyse the status of malnutrition, socio economic status, number of family members, monthly income, transport used by the subjects, occupation of their parents were considered and data was collected based on these aspects along with assessment of nutritional status. Nutritional status in terms of Triple Burden of Malnutrition was assessed using ABCD technique of Anthropometric Measurements, Biochemical Estimation, Clinical Examination and Dietary Intake. This technique helps to assess the nutritional

status of the selected subjects in a comprehensive manner and was given the prime importance for the study for considering as the indicator and the reflector of the health status of the selected subjects of the study groups. The selected subjects were screened based on the objectives framed for the study with the help of the questionnaire. The questionnaire was divided into different sessions (i.e.) to collect the necessary data for the study.

Demographic profile, dietary intake and lifestyle pattern were assessed. The present study aims to be a comprehensive study on the overall wellbeing of the target population (environmental, social and dietary factors) will also affect the health and nutritional status of an individual to a greater extent. The study is being framed on the basis of five objectives, where the selected subjects were screened and classified according to the requirements of the study and provided the recommended dietary intervention and health education to uplift the deficiency or conquer the surplus of any of the nutrients. The age group selected for the study was 18-21years girls (young adult women) and considered as one of the vulnerable groups with one or other form of health issues.

Socioeconomic status (SES) is an important indicator that links social standing and general well-being. SES significantly influences a person's quality of life, health, social status, and class. The Kuppuswamy, BG Prasad, and Udai Pareekh SES scales are the most extensively used methods for assessing the socio-economic profile. An online application created specifically for this purpose is used to update the salary range. The scale used to determine SES is based on the income domain and must be updated on a regular basis based on the Consumer Price Index for Industrial Workers (CPI-IW). However, each of the three scales has some restrictions and cannot be used simultaneously in urban and rural settings (Majumder, 2021).

Before executing the present study, an orientation cum awareness programme was organized with the support of higher officials of the college as part of the pre education process of the present research study. The programme was organized in online mode where both students and teachers of the selected departments attended. They were given a nutrition and health education on different topics covering the types of nutrients, importance of nutrition, triple burden of malnutrition with reference to cause, consequences, complications and preventive measures, deficiency diseases and so on to give a proper knowledge on the research topic so as to make them clear about the need of the study and their role in the present study. The selected subjects were also provided with online questionnaire (Google Form) to fill in questions which was divided into different sessions

to get the correct information to screen the subjects for the study. The subjects were screened based on the grade of malnutrition (ABCD techniques) and categorised as under nutrition, over nutrition and micronutrient deficiency. Five hundred and Seventy subjects (n=570) were provided with questionnaire. The questionnaire also contained a consent form for the blood sample collection. The selected 570 subjects were co-operative and ready to extend their support to execute the present study with their consent forms

3.1.5.Ethical Consideration and Confidentiality

In order to guarantee that the study is carried out in compliance with ethical principles and safeguards the participants' rights, safety, and well-being, ethical clearance is required for research involving human subjects. Before beginning a study, researchers need to get approval from a recognised ethical commission. Typically, presenting a research plan, informed consent forms, and other pertinent documentation to the ethics committee is the first step in getting ethical approval. The committee evaluates the informed consent processes, potential risks and benefits of the study, and adherence to ethical standards. The study has been presented for Ethical Clearance from the Institutional Human Ethical committee. The study had undergone three human ethical clearance (i.e.) Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore with the Registration no: **AUW/IHEC/FSN 21-22/FHP-34** and University of Calicut with registration no: **021/CUHEC/2023**, since Mercy College, the study area from where the data was collected comes under University of Calicut. The panel members during the 2nd Doctoral committee suggested an addition of Nutritional Supplementation so a second human ethical clearance from Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore with Registration No: **AUW/IHEC/FSN/22-23/FHP-3** was acquired. The study was also uploaded for Trial Registry in Clinical Trail Registry India (CTRI) as the study involved dietary supplementation. The CTRI Trial Approval number is **CTRI/2023/08/056062**. The Ethical Clearance certificates obtained and CTRI trail approval number are provided in Annexure I.

3.2.PHASE -II: Mapping of subjects for Nutrition Interventions

3.2.1.Conduct of the survey

The selected subjects were provided with the specially designed questionnaire for collecting socio-economic profile, dietary and lifestyle pattern of the selected subjects. Socio-economic profiling is an indicator of the morbidity and mortality status of an

individual. There were questions regarding the annual income, parent's occupation, and members of the family etc. to categorize the subjects into different socio-economic class with the help of Kuppuswamy Scale for socio-economic status. This profile plays a pivotal role in screening the subjects for Triple Burden of Malnutrition and gives an overall picture of the living condition, environment, cultural belief and lifestyle pattern of the selected subjects. The lifestyle pattern of the subjects was assessed as they could also be a causative factor for Triple Burden of Malnutrition. The questionnaire used to conduct the survey is provided in Annexure II.

3.2.2.Assessment of nutritional status of the selected subjects

3.2.2.1.Anthropometric Measurements

The Anthropometric measurements involves the study of measurements and proportions of human body. The measurements included height, weight, waist circumference, hip circumference, calculation for BMI and waist to hip ratio were recorded systematically for the selected subjects of 570.

3.2.2.1.1.Height

Body weight is not a reliable indicator of growth. Height of an individual plays a vital role in maintaining a healthy life. A person's height also revealed their prior experiences, but their weight merely shows their current state of health (Jeong *et al.,* 2017). The chosen individuals were instructed to stand straight on the level floor with their feet parallel and their heels, buttocks, shoulders, and backs of heads touching the wall to record their height using a non-stretchable measuring tape that was fastened to the wall. The arms were naturally hanging at the sides, and the head was held comfortably erect. A head piece (scale) was lowered, crushing the hair and contacting the top of the head and height was recorded to the nearest 1.0 cm. This process was repeated thrice, and the consistent reading was obtained. Height of the selected subjects (n=570) was recorded in centimetres.

3.2.2.1.2.Weight

The most popular and easily repeatable anthropometric measurement for assessing the nutritional status of the populace is weight. Since it measures overall mass, variations in body fluids, fats, muscle mass, skeleton, and other organs will all have an impact on weight and weight indicates their current nutritional state. After emptying the bladder and

wearing as little clothing as possible, weight is measured in the morning while standing straight up (Cohen *et al.,* 2015)

The present study investigator recorded each subject's weight using a reliable, portable digital weighing balance. The weight was measured precisely, to the closest 0.1 kg, and the recommended safety measures were taken before removing the weight. While recording the weight of the selected 570 subjects the electronic digital weighing system was frequently tested using standard weights.

3.2.2.1.3.Computation of BMI

Anthropometric measures were used to derive several indices and ratios. The Body Mass Index is the most widely used and recognised measure of body fatness. Table II depicts the grade of malnutrition based on BMI. World Health Organisation states that the Body Mass Index (BMI) is a straightforward measure of height and weight that is frequently used to categorise the various levels of malnutrition (WHO 2020). Table II highlights the grade of malnutrition based on BMI. Body Mass Index was computed with the following formula:

$$\text{BMI}=\frac{Weight(Kg)}{Height(m2)}$$

Table II. Grade of malnutrition based on BMI

Classification*	BMI (Kg/m^2)	Risk level
Under nutrition	Less than 18.5	Low
Optimum nutrition	18.5-24.9	Average
Over nutrition	25.0-29.9	Mildly increased
Obese Grade I	30.0-34.9	Moderate
Obese Grade II	35.0-39.9	Severe
Obese Grade III	≥40.0	Very Severe

*(WHO 2020)

3.2.2.1.4.Circumference Measurements

The hip and waist measurements were measured to compute the Hip to Waist Ratio (WHR) which is one of the several methods to classify and categorize the form of malnutrition.

3.2.2.1.4.1.Waist Circumference (WC)

The cost of producing an exact measurement of the visceral fat component makes it impractical for use in clinical settings. As a substitute marker of abdominal fat mass, WC is used, and WC is associated with higher cardio metabolic risk and is correlated with subcutaneous and visceral fat mass. At the thinnest point between the final rib and the pelvic crest, waist circumference was measured using fibreglass tape. After the patient exhales, the WC measurement should be performed with the patient standing with both feet touching and arms hanging freely. The measuring tape should be constructed of a material that resists stretching, be horizontal to the ground, perpendicular to the long axis of the body, and be applied with tension without applying pressure to the abdominal wall. The minimum waist (33%), the midpoint between the lowest rib and the iliac crest (26%), and the umbilicus were the most often utilised landmarks (Ross *et al.,* 2020). Waist circumference was measured and recorded for the selected subjects of 570.

3.2.2.1.4.2.Hip Circumference

With the measuring tape, parallel to the floor, the hip circumference should be calculated around the widest part of the buttocks. The 570 selected subjects were advised to wear light weight clothes and stand with their feet together, their arms at their sides, and their body weight uniformly distributed for both measurements (Cameron, 2020).

3.2.2.1.4.3.Waist to Hip Ratio (WHR)

Waist –Hip Ratio was calculated with the formula and the subjects were classified as under nourished and over nourished. All the measurements are the most crucial measurements for any research study related to nutritional status. Assessment of WHR was calculated as waist circumference (cm) divided by hip circumference (cm) (Lam *et al.,* 2015).

Based on the World Health Organization Asia Pacific Guidelines, modified BMI categorization for Asian populations and this was followed in the present study to identify overweight (23-24.99 kg/m2) and obesity (>25 kg/m2). For men, WC cut off of 95 cm was employed, and for women, a cut off was 85 cm and was used to define central obesity, considering WHR > 0.95 for men and > 0.85 for women to be high (Gadekar *et al.,* 2020). The WHR cut-off for Indian women is 0.85, as per the regulations (WHO 2020). Table III depicts the waist to hip ratio and their grades of malnutrition.

Table III. Waist to Hip Ratio

Grades*	Waist to Hip Ratio (WHR)
Underweight	≤ 0.80
Normal	0.81-0.85
Overweight	≥0.85

*(WHO 2020)

3.2.2.2.Biochemical Estimation

Biochemical estimation is the 2nd method in the ABCD technique. This sampling method is one of the most crucial methods to detect micronutrient deficiency. This sampling method uses any of the biological sample for assessment. Blood, saliva and swab are biological samples usually collected for this purpose. The current study has used blood sample for the assessment of biochemical profile of the selected subjects (Plate 1).

Plate 1. Collection of Blood Sample

The blood samples were collected from the selected subjects of 18- 21 year according to the parameters to be estimated. The amount of blood sample collected was 3ml from each of the selected subjects with the help of laboratory technicians. The blood samples were assessed for Haemoglobin, Serum Iron, Serum Folic Acid and Serum Calcium estimation using the standard procedure for Non-Cyanide method for Haemoglobin,

Spectrophotometry for Serum Iron and Calcium and ECLIA for Serum Folic Acid. The standard procedures are given in Annexure III. The results were shared with the study subjects to know about the biochemical profile for further process of the research study.

3.2.2.3.Clinical Examination

Clinical examination is the 3rd method in the ABCD techniques used to assess the nutritional status of the target group. The selected subjects were assessed for various clinical signs and symptoms (i.e.) hair colour, paleness in nail was assessed to note the nutritional inadequacy. This examination usually goes with the physical method to detect the nutritional adequacy of an individual. The physical appearance of the subjects was taken into consideration for this purpose. The subjects were examined for pallor, breathlessness, palpitation, hair loss etc. Medical History in terms of grade of malnutrition and nutrient deficiency condition of the selected subjects were also analysed. Medical History of the selected subjects helped in personalizing the diet for each of the selected subjects and considered for nutritional intervention. Their history of any disease, allergies, menstrual irregularities and bowel movement was examined.

3.2.2.4.Dietary Intake

Dietary intake is the 4th method in the ABCD technique of assessing the nutritional status. It is one of the several techniques used in assessing the nutritional status the selected 570 subjects and reflected the consumption of the selected subjects per day to meet the nutritional needs. The selected subject who were chosen for the study provided information on their meal and food consumption using one of two methods.

3.2.2.4.1.24-hour recall

A 24-hour food recall questionnaire was provided to the selected subjects to list down a day's meal to assess the subjects to meet the nutritional requirement. A food frequency table was also provided to them to record the frequency of food consumed by the selected subjects. Consuming a balanced diet with all five food groups and essential nutrients is crucial for maintaining optimal health. The 24-hour recall method is an effective tool to ensure if the subjects are meeting the daily nutritional needs. By closely examining the food intake over a 24-hour period, we can identify areas for improvement and make changes in the eating habits. This approach provides a comprehensive snapshot of the consumption patterns, allowing the researcher to pinpoint any nutritional deficiencies. Documenting the meals, snacks, and beverage choices gives the subjects with insights

needed to fine-tune diet. The 24-hour recall can be a powerful ally in reaching goals to support energy levels, promote healthy weight management, or simply maintain overall wellbeing. The capacity to reaffirm participants for correct recollection, high response rates, minimal respondent burden, brief interview durations, and sensitivity to variations based on ethnicity are some of the advantages of 24-hour recalls. Limitations include the possibility of participant forgetting, which can be difficult for older or younger participants, and the requirement for an expensive, qualified professional to conduct the interview. A single 24-hour recollection may not accurately reflect a person's regular diet, and professional coders are needed to transform data into nutrients, which can be an expensive and time-consuming process (Castell *et al.,* 2015). 24-hour recall was carried out with the help of Diet Soft software.

3.2.2.4.2.Food Frequency Questionnaire (FFQ)

The basic Food Frequency Questionnaire (FFQ) consists of two components: a closed food list and a frequency response section for selected subjects to report how often each food (e.g. banana) or food group (e.g. fruit) was eaten. For each item on the food list, the respondent is asked to estimate the frequency of consumption based on open or specified frequency categories, which indicate the number of times the food is usually consumed per day, week, month or year. Different types of FFQ are usually considered: non-quantitative (alternatively called qualitative), semi-quantitative or completely quantitative FFQs. Non-quantitative questionnaires do not specify any portion sizes (standard portions derived from other study populations or data sets might be added afterwards), whereas semi-quantified instruments provide a combination of individual or typical/standard portion sizes to estimate food quantities (standard portions are part of the food item line). A quantitative FFQ allows the respondent to indicate any amount of food typically consumed. FFQs are commonly used to rank individuals by intake of selected foods or nutrients (Gosadi *et al.,* 2017). The food frequency table included ICMR five food groups. The survey asked different food categories and food consumption habits to classify the subjects into frequent, occasional, and rare eaters. Time of meals, ingredients, quantity, and method of preparation were noted in the food diary and interview. It was employed to ascertain the consumption of various food categories. The techniques used for this study have been summarized in Table IV.

Table IV. ABCD Techniques used to Assess Nutritional Status

Anthropometric Measurement	Biochemical Estimation	Clinical Estimation	Dietary Intake
1.Height	1.Haemoglobin	1.Pallor (Conjunctiva, Palms, Nail Beds, Tongue)	1. 24-Hour Recall method
2.Weight	2.Calcium	2.Breathlessness	2.Food Frequency Table
3.Waist Circumference	3.Folic Acid	3.Dry scaly skin	
4.Hip Circumference	4.Iron	4.Fatigue	
5.Computation of Waist to Hip ratio		5.Head aches	
6.Body Mass Index (BMI)		6.Brittle nails	
		7.Bitiot Spot	
		8.Poor Eye Sight	
		9.Hair Loss	
		10.Bleeding gums	

3.3.PHASE - III Formulation and Evaluation of Dietary Supplements and Nutrition Education modules for Triple Burden of Malnutrition

In India, the prevalence of three forms of malnutrition – under-nutrition, micronutrient deficiencies and over-nutrition - are seen as the major significant public health problem. Young adult Indian women are particularly affected by this phenomenon because they are at an age where their body needs to be able to grow and develop properly but also need to be able to maintain a healthy weight. A recent study conducted by UNICEF Nutrition Strategy (2020-2030) showed that there has been a spike in the amount of people suffering with malnutrition even after years of trying to tackle the double burden of malnutrition. The most common form of malnutrition in India is under-nutrition. This occurs when people do not have enough food to meet their nutritional needs. This may be

because of their poor dietary pattern and poor quality and quantity of nutrients, such as protein, vitamins or minerals.

Nutrition education plays a major role in educating the selected subjects highlighting nutritional importance and health benefits of the present nutritional intervention studies. The nutrition education can be provided prior to the supplementation programme to provide an awareness among the selected subject to be a part of the supplementation. Nutrition education provides knowledge among the selected subjects about healthy eating and the importance of nutrition on their health. Nutrition education provides different orientation of nutrition and health. Nutrition education improves the knowledge and thereby improves the attitude and practices of the selected subjects to bring up an improvement in the nutritional status of the selected subjects. Nutrition education even helps the selected subjects to adopt the proper way of consuming foods and eliminates the myths behind the food and develops a healthy eating pattern among the selected subjects to promote their health status.

Dietary Supplementation is one among the nutritional intervention which provides a great impact on the nutritional status of the selected participants in the study group. The supplementation programme aims at providing specific amount of developed product to the selected participants for a specific duration.

3.3.1.Formulation and Evaluation of the Dietary Supplements for Nutritional Intervention.

The supplementation study is usually carried out for a period of 90 days to have a noticeable change in the nutritional status of the selected subjects. The supplementation was provided to the subjects in the category of three different groups in terms of under-weight, over-weight and micronutrient deficiencies. The amount to be supplemented to the selected subjects were decided after carrying out a pilot study where the subjects were provided with 50g,70g 100 g of the developed products and the most acceptable amount for supplementation was decided without any plate waste.

3.3.1.1.Formulation of Dietary Supplements

Different types of supplements were prepared to break monotony and also to fulfil the nutritional requirement of the selected subjects in the category of Under-weight, Over-weight and Micronutrient deficiencies. Formulation of dietary supplements are shown in Figure 1.

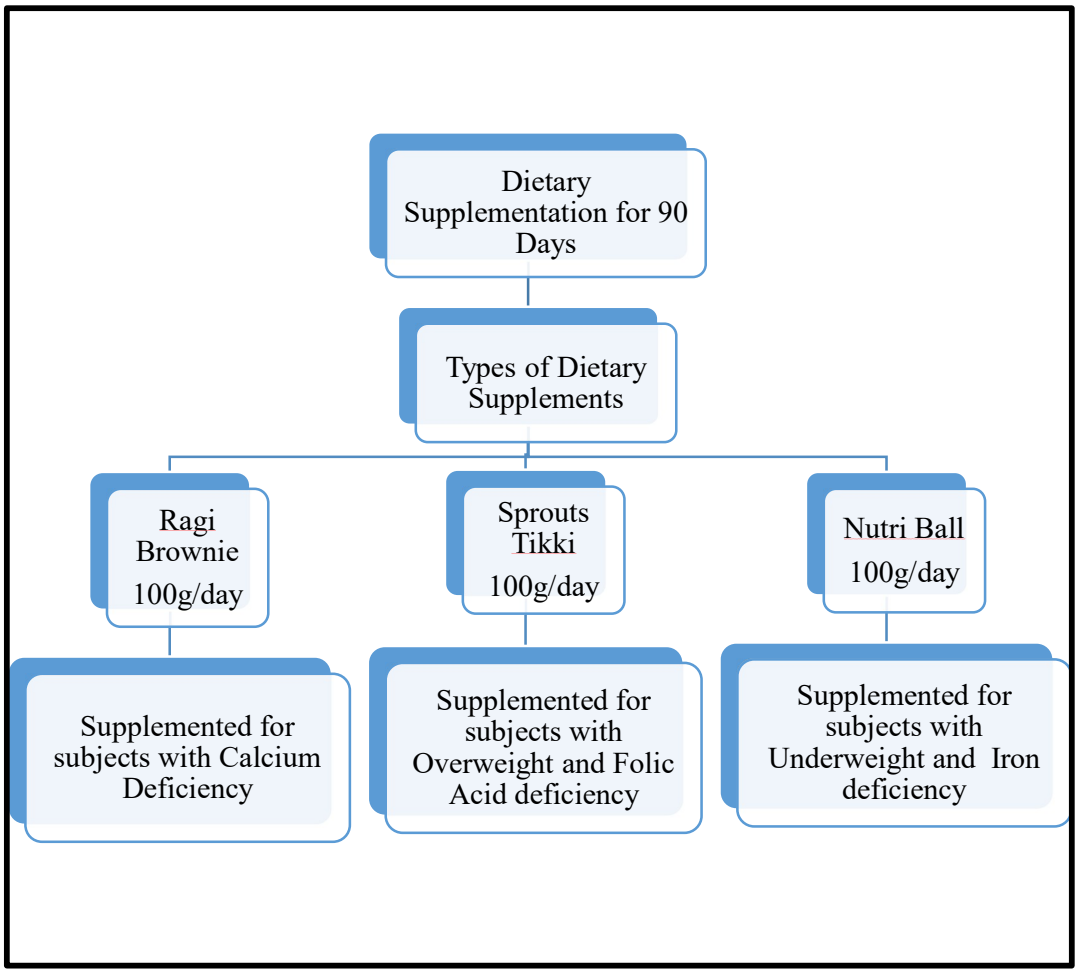


Figure 1. Formulation of Dietary Supplements

3.3.1.1.1.Ragi Brownie

Ragi Brownie is suggested for selected subjects with Calcium deficiency as Ragi is a good source of Calcium. Ragi flour was a replacement of all-purpose flour and used in different proportions to form different variations of Ragi Brownie. Sensory evaluation was executed to find the highly acceptable variation of this product. The quantitative analysis of the product was made to analyse the nutrients present in the product can address the RDA (recommended dietary allowance) of the selected subjects. Other ingredients used in the development of the product are curd, Jaggery, Vegetable Oil and Sesame seeds. Curd was included as it was also high in calcium content and help to tenderise the product while adding essential minerals like Sodium. Vegetable Oil was used as a binding agent and sesame seeds provided the nutty flavour essential for texture of product. The flow chart of

the preparation of Ragi Brownie is illustrated in Figure 2. The three variations of Ragi brownie are shown in Plate 2.

The product was designed as a dessert to ensure the consumption of the product over the duration of 90 days supplementation. Millet flour was blended with ragi flour in different proportions for multiple formulations to ensure the texture and taste of the product and was within the palatable parameters during sensory analysis. The different variations of Ragi Brownie and the ingredients used to prepare 100g of Ragi Brownie are shown in Table V. The formulated product was further analysed for its nutritional content. The ingredients used for the preparation of Ragi Brownie and its health action is depicted in Table VI.

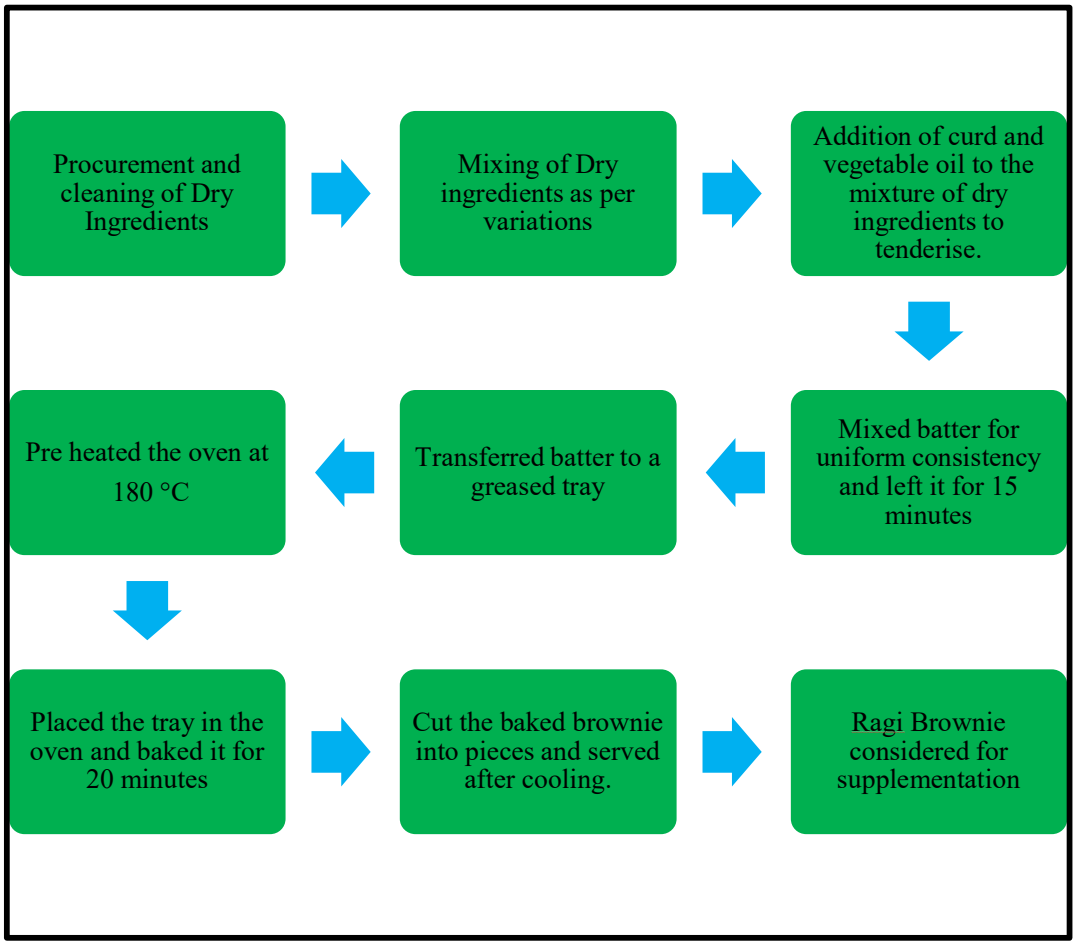


Figure 2. Steps involved in developing Ragi Brownie

Plate 2. Ragi Brownie in three Variations (RB1, RB2 and RB3) with Standard

Table V. Quantity of ingredients used in the three variations of Ragi Brownie

Ingredients	Variation 1 (RB1) (g)	Variation 2 (RB2) (g)	Variation 3 (RB3) (g)
Ragi Flour	50	30	20
Refined Wheat flour	-	20	30
Jaggery	40	40	40
Sesame seeds	20	20	20
Curd	50	50	50
Vegetable Oil	5	5	5
Cocoa powder	1	1	1
Baking powder	1	1	1
Total	167	167	167

Table VI. Nutritional contribution and Health benefits of Ingredients used in Ragi Brownie

Ingredients	Nutrient contribution	Health benefits
Ragi (Finger millet)	Iron and Calcium	• Involves in oocyte maturation • Successive follicular development • Helps in insulin signalling pathway
Jaggery	Iron and Energy	• Increases the Haemoglobin level and Prevents Anaemia.
Sesame seed	EFA Iron and Calcium	• Improves blood Iron and Calcium profile • Improves insulin sensitivity
Curd	Calcium	• Improves digestion • Improves immunity • Improves bone strength
Vegetable oil	Omega-3 fatty acids	• Promotes metabolism

3.3.1.1.2.Sprouts Tikki

Sprouts Tikki was **s**upplemented to the selected subjects having Folic Acid deficiency and Over weight.Whole bengal gram was selected as it has a high amount of folic acid .Research studies showed that sprouting of bengal gram and green gram further increases the availability of nutrient content of food grains and also enhances the taste the developed product (Akkad *et al.,* 2021). Spouts Tikki was an ideal food for the overweight subjects of the study as provides satiety due to its high fibre contents and prevents the frequent food consumption pattern of the selected subjects. Sprouts Tikki was baked to prevent any nutrient loss through the conventional methods of cooking (i.e.) shallow frying. All the ingredients were weighed on a digital balance to assure accuracy. Whole green gram and whole bengal gram were soaked in water for overnight. The soaked whole green gram and bengal gram were tied up in muslin cloth and allowed to have sprouting. The sprouts were steamed to make it soft then the sprouts were transferred to a bowl and mixed all the other ingredients (i.e.) chopped garlic, chilly powder, asafoetida and salt. The prepared mix was spreaded out and cut into a circle shape and placed in oven in combination mode at 180°C for 10 minutes. The process of baking ensured that the nutrients are intact in the developed product. Table VII shows the different quantity of ingredients used in the three

variations to make 100g of Sprouts Tikki and is depicted in Plate 3. The flow chart of the Sprouts Tikki formulation is depicted in Figure 3.

Plate 3. Different variations of Sprouts Tikki

Table VII. Quantity of ingredients used in the three variations of Sprouts Tikki

Ingredients	Variation 1 (ST1) (g)	Variation 2 (ST2) (g)	Variation 3 (ST3) (g)
Bengal gram (whole)	50	40	60
Green gram (whole)	40	50	30
Garlic	10	10	10
Chilli powder	2	2	2
Asafoetida	1	1	1
Salt	1	1	1
Total	104	104	104

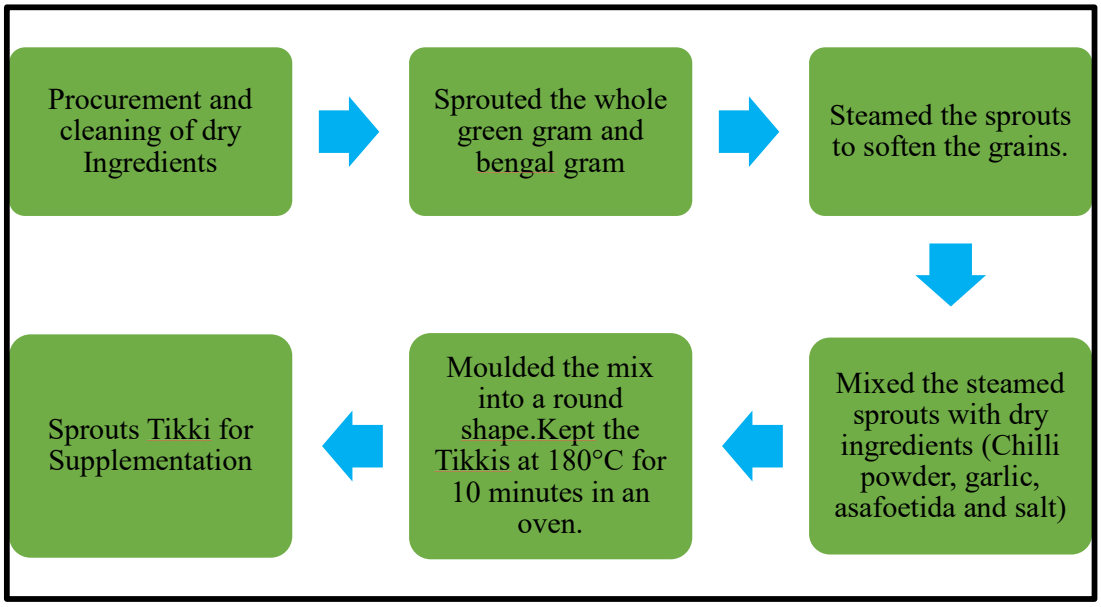


Figure 3. Steps involved in formulation Sprouts Tikki

Table VIII highlights the ingredients used in the preparation of Sprouts Tikki and its nutrient contribution with their health benefits.

Table VIII. Nutritional contribution and Health benefits of Ingredients used in Sprouts Tikki

Ingredients	Nutritional contribution	Health benefits
Bengal gram (whole)	Protein and Folic Acid	• High fibre helps in weight loss • Control colon cancer • Prevents constipation
Green gram (whole)	Protein and Folic Acid	• Prevents constipation • Adds bulk to the food
Garlic	Vitamin B6 and Manganese	• Wards off cold and cough • Improves digestion • Boosts immunity
Asafoetida	Phenolic Compounds	• Improves digestion • Cure whooping cough, stomachache and influenza

3.3.1.1.3.Nutri Ball

Nutri Ball is a nutrient dense product developed for the subjects with underweight and iron deficiency. The core ingredients used were the combination of millets and pulses to complement protein content and enhanced micro-nutrients content. Sesame seeds were also added to the Nutri Ball to improve the iron content and helpful for young adults who are suffering with thyroid and PCOS to get their menstrual cycle on regular interval. Sugar was substituted with jaggery by keep in mind the iron content of jaggery and also an easy access product by a common man. The ingredients were carefully weighed on a digital weighing balance. All the ingredients were dry roasted on a low flame. The dry roasted ingredients were powdered to a coarse powder on an electric mixer. The jaggery syrup was then added to the prepared powder. It was stirred continuously to prevent lump formation. The mix was used for the preparation of the ball. Plate 4 shows the variations of Nutri Ball. The different quantity of ingredients used in preparing 100g of Nutri Ball and its three variations are depicted in Table IX. The flow chart of Nutri Ball formulation is depicted in Figure 4.

NB1 NB2 NB3

Plate 4. Different variations of Nutri Ball

Table IX. Quantity of Ingredients used in Variations of Nutri Ball

Ingredients	Variation 1(NB1) (g)	Variation 2(NB2) (g)	Variation 3(NB3) (g)
Bajra	40	30	20
Bengal gram	10	20	30
Ground nut	10	10	10
Horse gram	20	20	20
Sesame seed	10	10	10
Dates	10	10	10
Jaggery	20	20	20
Total	120	120	120

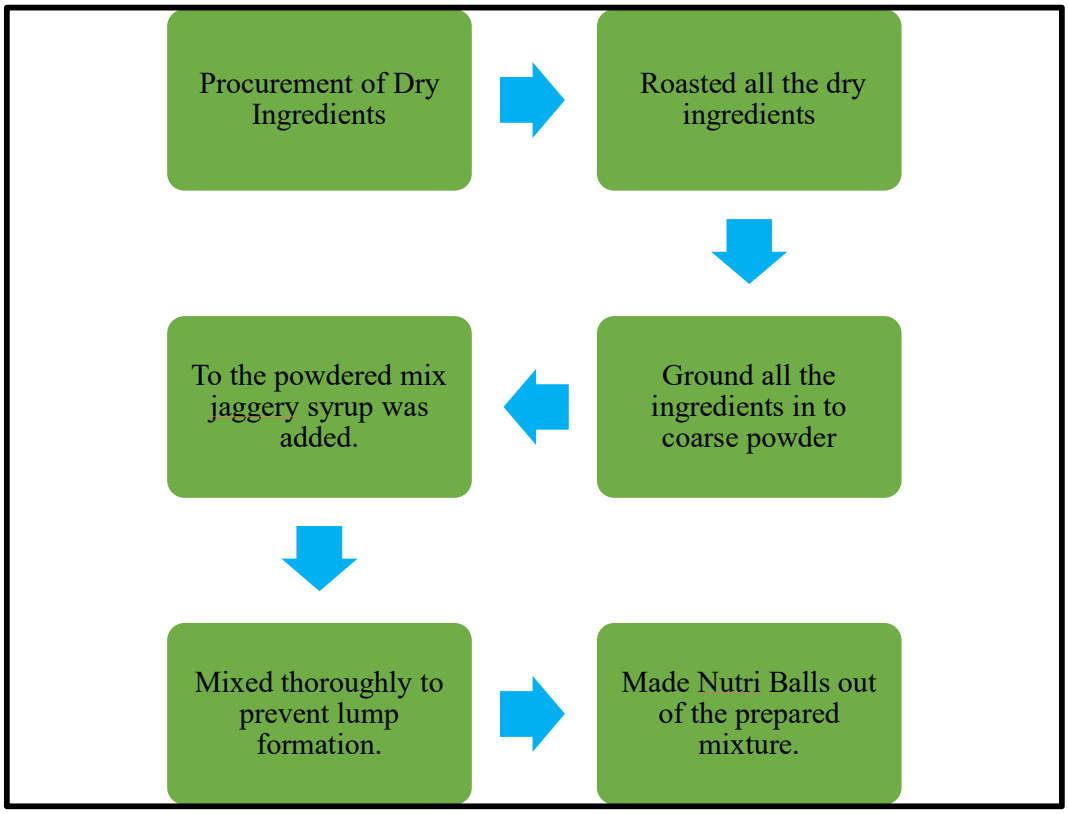


Figure 4. Steps involved in preparation of Nutri Ball

The nutritional contribution and health benefits of the ingredients used in the preparation of Nutri Ball are presented in Table X.

Table X. Nutritional contribution and Health Benefits of Ingredients used in Nutri Ball

Ingredients	Nutritional contribution	Health benefits
Bajra(Pearl millet)	Iron, ßcarotene, Selenium, Magnesium and MUFA.	• Controls glucose metabolism • Regulates insulin secretion
Bengal gram	Protein and Folic Acid	• High in fibre helps in weight loss and colon cancer • Sprouted gram increases the Vitamin C content • Prevents constipation • Prevents Folic Acid deficiency
Flax seed	Omega-3 fatty acids, Zinc, Potassium, Selenium and Phosphorus.	• Increases IGF 1 • Increases oocyte production • Reduces insulin resistance • Reduces dyslipidaemia and Insulin resistance.
Horse gram	Iron	• Boosts metabolism • Prevents Anaemia
Sesame seed Dates Jaggery	EFA, Iron and Calcium	• Improves blood Iron and Calcium level • Improves insulin sensitivity • Good source of Energy • Prevents Anaemia

3.3.1.2.Sensory evaluation of the Dietary Supplements

Sensory Evaluation is one of the preliminary steps in the process of product development. Sensory Evaluation is also known as Organoleptic Examination. The developed product will be assessed for various parameters. The sensory evaluation will be carried out by trained panels with nutritional background. The consumer won't accept food products if they don't satisfy their required standards for flavour, taste, texture, etc. (Ruiz-Capillas and Herrero, 2021). Product sensory evaluation is becoming increasingly important since it may be used to gather data for quality assurance, process variation assessment, cost cutting, product enhancement, shelf life, new product development, and market research. The process must be followed from a thorough scientific standpoint in order to get the

greatest benefits from sensory evaluation. The fundamental procedures for carrying out the sensory analysis are as follows:

a. Choosing the appropriate scale and panel members
b. Preserving appropriate environmental conditions and applying standard tools for the examination
c. Acquiring representative samples of the products
d. Samples should be prepared and presented for evaluation in a way that guarantees the samples acceptability and palatability
e. Choosing the appropriate statistical procedures and approaches

One often used tool for determining meal acceptability is the 9-point Hedonic scale. With four positive (like) and four negative (dislike) categories around the neutral "neither like nor dislike" category, it is set up as a balanced bipolar scale. The food industry has adopted the scale, and it is currently utilized for purposes measuring the acceptability of certain foods and beverages are. The panel members will be provided with a score card which mentions about the name of the product. The panel member was asked to mark the product out of 9 of different parameters. The ranking scale is called as hedonic rating scale. The most common hedonic scale is the nine-point hedonic scale ranging from 1 = Dislike extremely and 9 = Like extremely. The hedonic scale assumes that participants' preferences exist on a continuum and that their responses can be categorized into like and dislike (Lawless and Heymann, 2015).

A sensory evaluation of the developed product was carried out using the Nine-point Hedonic scale in the Sensory Laboratory of Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore. A total of 30 semi-trained panels from Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore were involved in the sensory evaluation. Three different types of the formulated products were evaluated for their colour, flavour, taste, appearance and overall acceptability. The total score of the sensory evaluation was calculated and the product with the highest sensory score was selected for nutrient analysis, shelf-life study (Stone *et al.,* 2020) and cost effectiveness. Plate 5 shows panel member involved in sensory evaluation. The Score card used for Sensory evaluation is given in Annexure IV.

Plate 5. Sensory Evaluation

3.3.1.3.Cost effectiveness of the Dietary Supplements

The development of product to cater to the needs of the subjects has to be made easily available economically, viable so that it can be consumed by all economic sections of the population as it is observed that the economically weaker sections are more prone to micronutrient deficient malnutrition rather than economically strong sections owing to food insecurity and low diversification in consumed food. The selected ingredients are such that they are regularly available household items. The cost of final product has been arrived at to check economic viability and availability of product for the malnourished subjects (Burns *et al.,* 2020). This aspect was considered and cost effectiveness of the formulated supplements used for dietary intervention were assessed. The cost of the developed product was also compared with similar available commercial product.

3.3.1.4.Nutrient Analysis of Dietary supplements.

3.3.1.4.1.Nutrient Analysis

Nutrients in the formulated products were analysed using the standard procedure and given in Table XI. The nutrient analysis for the highly acceptable variation was performed to check the adequacy of nutrients to meet the nutritional requirement of the selected subjects using the developed products. The proximate nutrients in the developed products were analysed and the nutrients were Carbohydrates, Energy, Protein, Fat, Calcium, Iron and Folic Acid, Dietary Fibre and Crude Fibre. Procedure/Methods followed in the estimation of the above mentioned nutrients are given in Annexure V.

Table XI. Procedures/Methods followed in Nutrient Analysis

Nutrients	Procedure/Method
Moisture	AOAC 2015
Total Ash	AOAC 2015
Total Carbohydrate	FSSAI Manual 2016- Anthrone Reagent Method
Energy	FAO Manual 2015-Bomb Calorimeter
Protein	AOAC 2015-Kjeldal Method
Fat	AOAC 2015- Soxhlet Extraction method
Calcium	AOAC 2015Titration Method
Iron	AOAC 2015-Atomic Absorption Spectrometry
Folic Acid	UV-Visible Spectrometry
Crude Fibre	AOAC 2015-Fibroton method
Dietary Fibre	AOAC method-Gravimetric Analysis

3.3.1.4.2.Anti-Nutrient Analysis (Phytic Acid Analysis)

The Phytic Acid analysis was carried out using the methodology adopted by Pramitha *et al.,* (2020). The analysis of Phytic acid in the developed product was carried out as the major anti-nutrients in food groups is Phytates. Therefore phytic acid analysis was carried out in the developed product as the major ingredients in all these products are pulses and millets which contains high amount of phytates as anti-nutrients.

The impact of phytic acid on nutritional bioavailability in food grains is a cause for concern. The organic form of phosphorus in plants, called phytic acid, binds to positively charged mineral ions such as calcium, iron, and zinc, so influencing the bioavailability and digestibility of nutrients. Phytic acid levels of food grains can be effectively lowered by using conventional processing techniques including soaking, fermentation, and germination, which also improves the availability of minerals. Germination increases vitamin production and lowers phytic acid concentration, but fermentation optimises pH to breakdown phytic acid. Different processing techniques have varying effects on the decrease of phytic acid, with fermentation demonstrating notable advantages (Sheethal *et*

al., 2022) (Boncompagni *et al.,* 2018). The procedure for Phytic Acid analysis will be provided in Annexure V.

3.3.1.5.Microbial Count of Dietary Supplements

3.3.1.5.1.Total Fungal Count (Yeast and Mould Count)

The total fungal count of the dietary supplements were analysed by Standard Operating Procedure by Colony Count Technique at 25°C. The shelf-life was assessed at different days depending up on the moisture content in the developed product. The colonies of the fungus were counted with a colony counter using IS 5403: 2012 method.

3.3.1.5.2.Total Plate Count

The total plate count of dietary supplements were carried out by Standard Operating Procedure for Enumeration of Micro-organisms Colony Count Technique at 30°C (TPC). The shelf-life of the developed product was assessed at different days depending upon the moisture content to check the growth of micro-organism (mold, yeast, bacteria) present in the developed product. The colonies of microbial growth were counted with a Colony Counter using IS 5402: 2012 method.

3.3.1.5.3.pH

The pH of the dietary supplements was checked at regular intervals. FSSAI Electrometric method was used to analyse the pH of the dietary supplements. pH meter is used to measure the pH value. To prevent the growth of harmful bacteria that can ruin food or degrade the end product's taste and quality, pH levels must be closely recorded. As the result, precise pH measuring tools can guarantee both product quality and adherence to food safety laws.

3.3.2.Development and Validation of Nutrition Education Modules for Triple Burden of malnutrition

3.3.2.1.Development and Validation of Nutrition Education modules

The present study included a nutrition education programme for the selected subjects having one or other form of triple burden of malnutrition. A pre-nutrition education class prior to the blood sample collection was carried out through online mode as it was conducted during pandemic time. The pre-education helped the selected subjects to be aware of the importance of the project and the health benefits of the study. The nutrition education was

carried out for three months to the experimental group subjects using different mode of education in the forms of booklets, bookmarks and online platforms.

The booklet was made attractive with pictures and used simple language for easy understanding of various concepts of nutrition and health. The booklet was handy and can be used for easy reference of any topic. The contents of Nutrition and Health Education modules were on Balanced diet, Food Guide Pyramid, Importance of Nutrition, Concept of Triple Burden of malnutrition, Foods to be consumed for different components of Triple Burden of Malnutrition.

The Bookmarks consisted for different details of foods sources of different micro and macro nutrients in picture forms for easy understanding. These bookmarks were useful to the selected subjects to understand and choose food according to their nutritional importance

Diet plans for various deficiency in the selected subjects were also prepared to provide them with a dietary guideline for proper uptake of nutrients required to meet their nutritional requirement. Dietary guidelines play a crucial role guiding the selected subjects in a systematic lifestyle for better health.

The study subjects were also educated to know about spoon, cups and portion size and to guide them to use in their in daily dietary plan. All the nutrition education tool was validated by physicians, dieticians and academicians.

3.3.2.2.Imparting Nutrition Education to the Selected Subjects

3.3.2.2.1.Selection and Grouping of Subjects for Nutrition Interventions

Young adult women (18-21 years) from Mercy College, Palakkad, Kerala were selected as the subjects for the present study. Prior to the actual conduct of the supplementation and nutrition education and good rapport was established among the college higher authorities, teachers , students and their parents through proper counselling .The purpose and procedure involved in the supplementation study were explained. The subjects were also provided with an informed consent for the research study. A total of 570 young adult women in the age group of 18-21 years were screened for the Triple Burden of Malnutrition. The number of selected subjects who agreed to participate in the research were reduced to 500 since few subjects were hesitant to take the dietary supplements and be part of the nutrition education programme for a period of 90 days. Using the purposive sampling

method, a sample of 500 young adult women who classified into the categories of underweight, overweight, and micronutrient deficiency—250 for the experimental group and 250 for the control group was chosen from for the nutritional intervention research. The control group was matched in terms of socio-economic status, anthropometric measurements and blood profile and recommended to involve in nutrition education programme for the period of three months.

Young adults need nutrition instruction because this is the time when they commonly follow a dietary habits that last a lifetime. Encouraging college students and other young adults to read nutrition labels, like the Nutrition Facts label, can help them eat better. Studies have shown the potential of healthy eating education to enhance the eating habits of young adults. Specifically, combining of knowledge transfer with mobile applications can be very successful in encouraging healthy eating among youth who are accustomed to using technology. (Buyuktuncer *et al.,* 2018).The nutrition education was imparted to the selected subjects of 250 in experimental group with the help of Nutrition education videos were the selected subjects were provided with a comprehensive knowledge on various concepts of nutrition (i.e.) Malnutrition, RDA etc. The selected subjects in the experimental group were provided with individual attention needed by subjects to carry out this nutritional knowledge in their life.

The selected subjects in experimental group were also provided with booklets and bookmarks on 'Triple Burden of Malnutrition' to enhance their nutrition knowledge (Plate 6). The booklet was translated to the regional language for a comprehensive understanding. It was provided to the subjects during the nutrition education period. The subject could comprehend the contents as it was in simple language. The selected subjects made aware of the importance of proper nutrient intake for better nutritional status. A practical session on the diet planning and preparation was carried out by the selected subjects were enthusiastically participated in the practical session and showed their keen interest on the food, nutrition and health (Plate 7). They were also offered a certificate course on 'Food Science and Nutrition for Lifestyle Diseases' for a time period of three months as the request of the college authorities. An online exam was also conducted to evaluate the study content (Plate 8), with the support of the College authorities. The certificate provided by the college authority for conducting the certificate course is provided in Annexure VI.

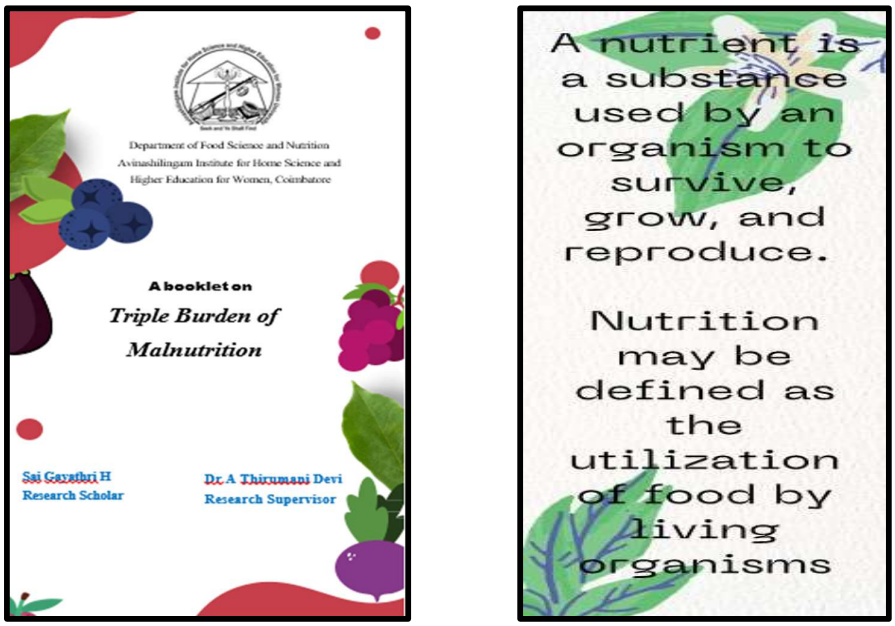


Plate 6. Booklet and Bookmarks for Nutritional Education

Plate 7. Subjects actively involved in healthy diet preparation as part of nutrition education

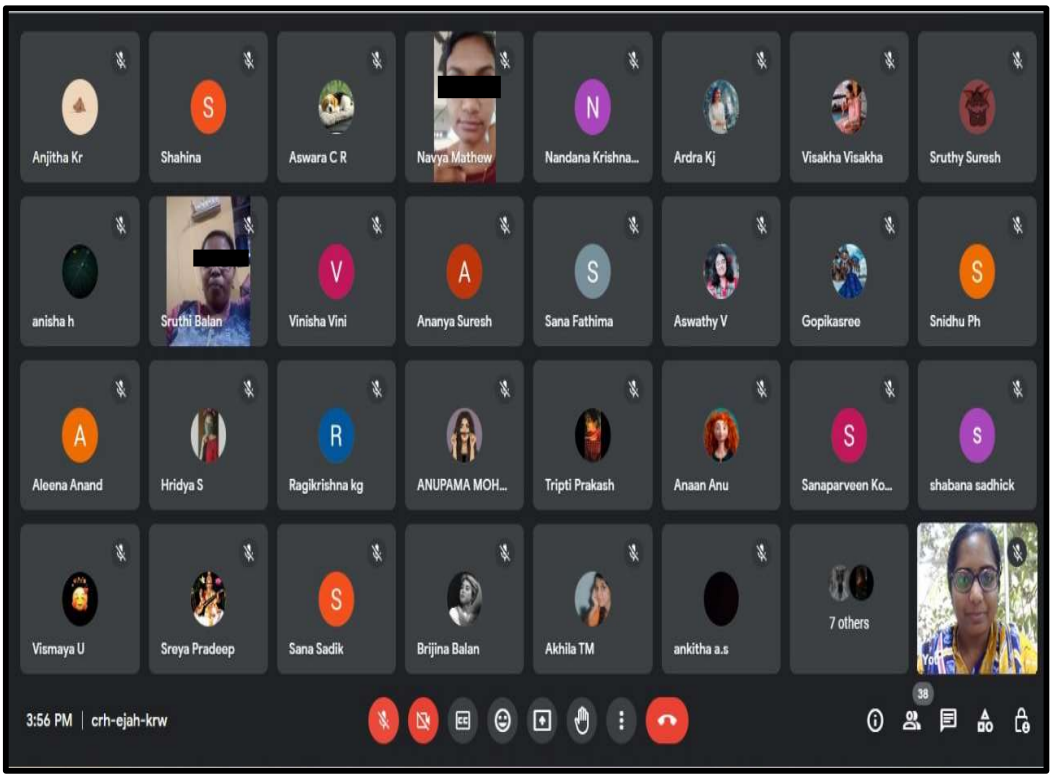


Plate 8. Online Exam for the Experimental Group Subjects (n= 250)

The Bookmarks were provided to selected subjects in experimental group as part of nutrition education programme. They used these bookmarks while reading any book and acted as a reminder about different sources of nutrients. These bookmarks had a great impact in understanding the sources and reminded the selected subjects to check on the frequency of intake of different food in their daily food intake.

A WhatsApp group was formed to provide nutrition education. WhatsApp group made communication easier. It provided easy access to the selected subjects. The selected subjects were asked to provide pictures of the food they are consuming every day as a procedure to assess the amount and variety in food they are consuming every day to ensure that the nutritional need of the selected subject is met. The WhatsApp group was utilized to provide the selected subjects with various videos regarding the importance of balanced diet, my plate concept etc. The selected subjects also used to clarify their quires about their diet and amount of food to be consumed to prevent the consequences of their health issues and promote their health status (Plate 9). Follow up session was carried in the form of games and quiz. The impact of the nutrition education was assessed using a KAP study.

Plate 9. Sample of WhatsApp page used for Nutritional Education

3.3.2.3.Diet Counselling to the Selected Subjects about Dietary Intervention

The selected subjects were assessed for various grades of malnutrition in terms of Triple Burden of Malnutrition based on their nutritional status and were provided with the customized diet suggestions and diet charts for each of their health issues covering the importance of Triple Burden of Malnutrition and advised them to have the follow up session once in two weeks to assess their nutritional status. The diet chart included foods from Basic Five food groups to meet their daily nutritional requirements. Customized diet modules were provided to each of the selected subjects by keeping in mind their preferences and other health issues. A follow up session of diet counselling was carried out in an effective way. The selected subjects were asked to post pictures of their meal consume daily in the WhatsApp to monitor their regularity in following procedures involved in nutrition interventions (Plate 10). The changes in the meal plan was carried out one in week and monitored. The diet suggestion was one of the sustainable step to improve the nutrition status of young adult women. All the diet charts were validated by a dietician. The diet charts validated by a dietician are submitted in Annexure VII.

Plate 10. Sample of WhatsApp used for Diet Counselling

3.3.2.4.Website Development to create awareness about Nutrition and Health to the selected subjects

Information dissemination can be done in various modes. Some modes reach far more audience than others. Each are bound to have their own advantages and disadvantages. But nothing comes close to the amount of audience to be reached using a Website. Websites provide multiple advantages compared to any other form of educational content. It is dynamic in nature while engaging audiences and providing sufficient time for each to consume content, self-paced, while acting as a means of communication. The content passed on through a website can be updated regularly to incorporate new findings and engage the audience while ensuring timely content is passed down to the end user (Manhas, 2017).

A website ensures consolidation of all the relevant content at a place duly providing scope for including future findings. A website was developed to ensure dissemination of information regarding nutrition with the title "NUTRITION4U" at domain "nu3tion4you.blogspot.com." The website was used as a means of education for the subjects regarding the healthy food habits. Regular posts were made available on various topics. The posts included information regarding importance of food, different groups of food, healthy living habits, and benefits of consuming readily available food sources. Information regarding the nutritional importance and health benefits of macronutrients and micronutrients was included. Posts on dietary fibre and water also provided to the selected

subjects. Posts on micronutrients like Iron, Calcium Iodine, Vitamin C, Folic Acid, Vitamin A, Vitamin E and Vitamin D were discussed. It also highlighted the sources and health issues related to deficit and surplus of these nutrients. The posts were designed in a way to emphasize, the selected subjects, the importance of including the micronutrients in their diet. Recent studies by Ritchie and Roser (2017), found that the focus on macronutrients consumption and calorie count has resulted in increased number of micronutrient deficiencies. Hence the need to move away from dual burden of malnutrition including over-nutrition and under-nutrition and adopting triple burden of malnutrition including over-nutrition, under-nutrition and micronutrient deficiency, also known as hidden hunger. This aspect also emphasized in these modules. Plate 11 shows the image of home page of the website used to impart nutrition education.

Plate 11. Website Home page and Visits

The need of the hour is to move away from one size fits all approach adopted till now to overcome the malnutrition vows of the country. It is suggested to adopt a nutritional diet being followed by everyone as per their requirement and make regular adjustments. Nutritional education is a must to understand the nuances of such adjustments and adopt such eating habits regularly to eradicate malnutrition from the country. The website is a small step towards educating the subjects on their diet and educate the subjects on the hazards of consuming food high in sugar and fat and make timely adjustments to their diet to overcome the deficiencies that are to plague the population consuming such diet. It is to be understood that the subjects suitable for adoption are not only unhealthy subjects who suffer from malnutrition but also those who are healthy to avoid falling into unhealthy eating habits and damaging their health especially as globalisation trends are on the rise. At the time of the study period the selected subjects were permitted to avail these facilities to enhance the nutritional knowledge.

3.4.PHASE -IV: Effect of Nutrition interventions on nutritional status and nutritional knowledge of Triple Burden of Malnutrition among the selected subjects

3.4.1.Effect of Dietary Intervention on Nutritional Status of the selected subjects

Dietary Intervention aimed at provision of food or nutrients directly to target group of population who are at risk of developing malnutrition constitute a familiar strategy pursued by health and social welfare sectors in many developing countries including India. The underlying principle of this approach is to supply the deficit or missing nutrients either through food which is habitually consumed or through its administration in medicinal or nutritional form at regular and periodical intervals. This approach is short term in nature and can hardly be expected to eradicate the root cause of malnutrition. It is realised that the only logical and certain way of overcoming malnutrition on a permanent basis is through economic growth, which ensures people to consume diet, adequate in quantity and quality and obtain good health care. But it takes long time and cannot solve immediate problems of malnutrition. Thus, the short term interventions are complementary to the long term strategies of socio-economic development. Considering all these aspects, a short term strategy using nutritional supplements were formulated and effectiveness was evaluated on their nutritional status.

The developed dietary supplements were supplemented to the selected subjects based on their nutritional status for a period of 90 days. The selected subjects were provided

with particular nutrient rich food formula for their health issues in terms of under-nutrition, over-nutrition and micro-nutrient deficiency condition. The selected subjects were provided with developed food products for five days in every week for three months. The selected subjects were supervised constantly to make sure that they consumed the food product properly to meet their nutrient requirement and also provided with a comprehensive knowledge on the nutritional importance and health benefits of the developed dietary supplements to fulfil their needs and also created awareness of the interaction between food nutrition and health .The were also aware about the health benefits of the developed dietary supplements in terms of food supplements on their health promotion.

The developed dietary supplements was helped to meet their one-third of RDA of the selected subjects. Each food products were weighed and packed with weights of 100g of Ragi Brownie, Sprouts Tikki and Nutri Ball for supplementation to each of the selected subjects in the experimental group for five days in a week for a period of 90 days. The products were provided to the selected subjects during the time of their interval for five days a week with the physical support of class teachers. Plate 12 showed the supplementation study executed among the selected subjects with triple burden of malnutrition health issues.

Plate 12. Subjects involved in Supplementation Study

For the present study, nutritional anthropometry, biochemical estimation, clinical examination and individual dietary intake by dietary recall method were used to assess the

effect of dietary intervention on nutritional status of the selected subjects involved in the experimental and control group before and after nutritional intervention for the period of three months.

3.4.1.1. Anthropometric Measurements

Assessment of nutritional status is a comprehensive evaluation of person's health status using socio-economic, health and nutritional status. Anthropometry is the universally, applicable, inexpensive and most sensitive parameter for assessing the nutritional status of the selected subjects in the experimental (n=250) and control groups (n=250). The BMI and WHR of the selected subjects in experimental and control group were recorded post. These parameters were recorded for the study subjects, before and after nutrition intervention programmes of supplementation and nutrition education.

3.4.1.2.Biochemical Estimation

Effect of nutrition supplementation was assessed with pre and post blood profile of the selected subjects. The blood samples of the selected subjects were collected to assess the effect of nutritional supplementation on the blood profile. The blood samples were collected before and after three months of nutrition intervention in experiment and control group were examined for Serum Iron, Serum Folic acid and Serum Calcium profile of the selected subjects. The increase or decrease in any of these parameters express the effect of nutrition intervention.

3.4.1.3.Clinical Examination

Clinical examination was conducted before and after nutritional interventions for all the selected subjects in experimental and control group using a validated questionnaire. The subjects were asked to mark their answers in the questionnaire provided to them to assess the effect of nutrition interventions. The increase or decrease in any of sign and symptoms of various deficiencies express the effect of nutrition intervention.

3.4.1.4.Dietary Intake

The selected subjects in experimental and control groups were assessed for their 24-hour dietary intake to assess if there is any increase or decrease in nutrient intake of various macro and micro nutrients. The mean intake of each subject was recorded.

3.4.2.Effect of Nutrition Education on Nutritional Knowledge of the selected subjects in the study groups

KAP (Knowledge, Attitude and Practice) is an effective tool in gathering quantitative and qualitative information to evaluate the nutritional knowledge of the selected subjects. This type of data collection revealed the misconception or misunderstanding that is be an obstacle to nourish the potential in any field of health and nutritional aspects. KAP study is one of the effective tools in transitioning the subjects from misunderstanding to a proper knowledge to change the attitude and also to follow it in their day to day life. This survey helped to elaborate on the extent to which a person needs to provide knowledge to bring about a change in selected subjects. It acts as a baseline to assess and help the subjects to enhance their health and related behaviours for the optimum health status. They can be used to find correlations between these variables and are intended to offer insights into the relationships between knowledge, attitudes, and practices (Al Ahdab, 2021) (Habib *et al.,* 2023).

An assessment of the study group of population's knowledge, attitudes, and practices on a given issue is the goal of a Knowledge, Attitude, and Practice (KAP) study. KAP investigations are widely utilized in public health research to assess the efficacy of treatments and to pinpoint knowledge and behaviour gaps and to find areas where people are misinformed or lack understanding about a given subject. With this data, focused interventions to enhance behaviour and knowledge can be created (Yousaf *et al.,* 2020).

Knowledge and behaviour-improving interventions was assessed for effectiveness using KAP research. Researchers was ascertain that the intervention was helpful in enhancing knowledge and behaviour by comparing the KAP study findings before and after the nutrition intervention for the study period of three months among the selected subjects in the experimental and control groups (Kutikuppala *et al.,* 2021).

KAP studies also offered important information on the attitudes and beliefs of the study population. Using this data, treatments that have a higher chance of being accepted and successful can be created (Singh *et al.,* 2022).

KAP of selected subjects of the experimental and control groups were evaluated using a specially designed questionnaire. Three sessions were required to complete the KAP survey. Each lesson included questions to gauge subjects' understanding, attitudes, behaviour, and practice to analyse the effects of nutritional education on the nutritional

knowledge of the selected subjects in the study groups before and after nutrition education. The questionnaires of the KAP study is given in Annexure VIII.

3.5.PHASE - V: Statistical Analysis and Interpretation of data

In intervention studies, statistical analysis is essential because it allows researchers to evaluate how an intervention affects a certain result. Researchers can ascertain whether the intervention had a substantial impact on the result and whether the observed effect is the result of the intervention itself or random variation by applying the proper statistical techniques. This data is crucial for directing future research and practice as well as for making well-informed decisions about the intervention's efficacy (Li *et al.,* 2021).

Data must be organised after gathering and combined to produce the required results. Systematically, the results of the effect of various nutrition interventions on reducing or relieving the symptoms and consequences of the triple burden of malnutrition were also interpreted using statistical analysis. To investigate the participant knowledge level, demographic profile, dietary and lifestyle habits, BMI, and incidence of triple burden of malnutrition, descriptive statistics like range, percentage, and mean were used in suitable data compilation. To determine the relationship and distinctions between factors as well as the impact of nutrition interventions on the nutritional status of the selected subjects in the category of triple burden of malnutrition, inferential techniques like correlation and chi-square were used. In chapter IV Results and Discussion, the acquired data were covered in detail highlighting Percentage, mean + SD were used to assess descriptive measures. Karls Pearson correlation was used to do the correlation analysis. To identify the relationships and discrepancies between the variables, inferential statistics like correlation and chi-square were used. For numerical variables such as weight, waist-hip ratio, and BMI, a paired t-test will be used. Using an independent sample T-test, compare the means. Paired t-test was used to compare within groups to assess the importance of within-group change. By adjusting for the baseline values, an analysis of variance was used to compare three groups. One way ANOVA was used to analyse the data for sensory evaluation. SPSS was used to analyse the data.

In conclusion, the number of groups, the type of data, the distribution of the data, and the availability of a pre-treatment measurement all influence the statistical test selection. To make sure the right method is utilised for your study, you need to consult with a statistician or methodologist.