RESULTS AND DISCUSSION

The results and discussion pertaining to the present study 'Triple Burden of Malnutrition in Young Adult Women (18-21 years) and the Effect of Nutrition Interventions on their Nutritional Status and Nutritional Knowledge' are presented under the following aspects.

Phase-I

4.1.Socio- economic and Demographic profile, Life style pattern and Medical History of the selected subjects

4.1.1.Socio-economic and Demographic Profile

Socio-economic profile is the key element in understanding the society and their dynamics. Socioeconomic and demographic profile refers to the social and economic conditions that influence the quality of life of an individual and community, in terms of family income, educational status, occupation, social background and access to avail resources whereas demographic profile focuses age, sex, marital status, family size and geographic location etc. These aspects were carried out in socio-economic and demographic profiling was conducted among the selected 570 subjects. Socio-economic status is an indicator for the family's health and access to the resources. The socio-economic status of the selected subject was evaluated using three factors (i.e.) family income, level of education and occupation of head of the family. Modified Kuppuswamy Scale (2022) is used to assess the socio-economic status of the urban residents. Thus, in turn socio-economic status is an indicator for nutritional status of a family (Sood *et al.,* 2023). It is also important that these data influenced individuals' nutritional status and lifestyle pattern and also played a vital role in positive health, functional efficiency and productivity. Table XII depicts socio-economic and demographic profile of the selected subjects.

Table XII. Socio –Economic and Demographic Profile of the selected subjects

Socio –Economic and Demographic profile		Frequency(n=570)	Per cent
Age(years)	18	108	19
	19	94	16
	20	216	38
	21	152	27
Religion	Hindu	165	29
	Christian	233	41
	Muslim	172	30
Educational Status	1st Year UG	203	36
	2nd Year UG	367	64
Marital Status	Married	87	15
	Unmarried	483	85
Area of Residence	Urban	407	71
	Rural	163	29
Type of Family	Joint	157	28
	Nuclear	413	72
Number of Family Members	2	53	9
	3	62	11
	4	298	52
	5	157	28
Father's Education Qualification	Primary	11	2
	Secondary	133	23
	Under graduation	212	37
	Post-graduation	209	37
	Ph.D.	5	1
Mother's Education Qualification	Primary	14	2
	Secondary	69	12
	Under graduation	333	58
	Post-graduation	146	27
	Ph.D.	8	1
Mother's occupation	Government	117	21
	Private	196	34
	Self employed	165	29
	Home makers	92	16
Father's occupation	Government	302	53
	Private	103	18
	Self employed	165	29
Family Monthly Income	≥184,376	11	2
	92,191-184,370	87	15
	68,967-92,185	96	17
	46,095-68,961	52	9
	27,654-46,089	233	41
	9232-27,648	89	16
	<9226	2	1
Socio-Economic Class	Upper Middle	106	19
	Lower Middle	409	71
	Upper Lower	55	10

Demographic variables such as age, gender, and ethnicity can significantly impact susceptibility to malnutrition, with studies showing that factors like low socioeconomic status, illiteracy, rural residence, and gender are linked to higher rates of malnutrition. Socioeconomic indicators, including education, occupation, and income, are also key determinants of diet quality, with higher SES individuals more likely to have healthier food habits. Incorporating these demographic and socioeconomic variables enhances the validity of nutritional research by accounting for potential confounding factors and identifying the specific contributions of each indicator to food choices and nutritional status. Understanding the overall socio-economic context is essential for explaining nutritional disparities and developing targeted interventions to address malnutrition in vulnerable populations (Alkerwi *et al.,* 2015).

The socio-economic profiling of the selected subjects (n=570) stated that among the selected subjects, 19 per cent of selected subjects were of the age 18 years, 16 per cent were of 19 years, 38 per cent were of 20 years and 27 per cent were of 21 years. The subjects were further divided into their religious practices and the results depicted that 29 per cent were Hindu, 41 per cent were Christian and 30 per cent belonged to Muslim. The educational status of the selected subjects stated that 36 per cent of the selected subjects were pursuing 1st year of graduation and 64per cent of the selected subjects belonged to 2nd year of graduation. Among the selected subjects, 15 per cent were married and 85 per cent were unmarried. The result stated that 71 per cent of selected subjects were from urban areas and 29 per cent belonged to rural areas. The selected subjects in the urban area had an easy access to health facilities and other amenities including their educational institutions. 28 per cent of selected subjects belonged to joint family system and 72 per cent belonged to nuclear family system. Nine per cent of family consisted of two members. 11 per cent consisted of three members, 52 per cent consisted of four members and 28 per cent consisted of five members. As the number of family members increased the quality and quantity of food available for each member in the family decreases and will lead to them facing other forms of malnutrition. The results of father's education qualification stated that 37 per cent were post graduate and 23 per cent only had secondary education. The results of mother's education qualification revealed that 58 per cent were graduate and 27 per cent were post graduate. The results of mother's occupations showed that 21 per cent has a government job, 34 per cent worked in private sector, 29 per cent were self-employed and 16 per cent

were home makers. The results of father's occupation depicted that 53 per cent were in Government sector, 18 per cent were in private sector and 29 per cent were self-employed. The result regarding the monthly income of the family stated that monthly income of the family is divided in to seven categories of ≥ Rs 184,376, Rs 92,191-184,37, Rs 68,967-92,185, Rs 46,095-68,961, Rs 27,654-46,089, Rs 92332-27,648 rupees and < Rs 9226 and number of selected subjects in each above mentioned group are two per cent, 15 per cent, 17 per cent, nine per cent, 41 per cent, 16 per cent and one per cent respectively. The division of monthly income was carried out based on revised Kuppuswamy scale (2022). The income of the family plays a major role in procurement of commodities for the family and providing nourishment to the members of the family for promotion of health, prevention of malnutrition and fostering sustainable food system. According to the revised Kuppuswamy scale (2022), the selected subjects were assessed based on the score they have earned with respect to the education of head of the family, occupation of the head of the family and monthly income of the family. Therefore, the results depicted that 19 per-cent were Upper-Middle income class, 71 per cent belonged to Lower-Middle class and 10 per cent belonged to Upper-Lower class.

In a study conducted by Harisha and Ravikanth (2021) it was stated that using a socio-economic profile in a community nutrition study offers several key benefits in terms of providing a comprehensive understanding of the demographics, housing, economic characteristics, and land use within the community. This information is crucial for assessing potential impacts on nutrition and food security, and for developing tailored interventions that address the specific needs and challenges of the community. Additionally, it encourages economic resilience by diversifying local food economies and reducing dependency on external factors, which can improve the sustainability and accessibility of nutritious foods.

4.1.1.1.Medical History

Medical History was being collected as a screening procedure to examine the morbidity of the subjects selected for the study. The selected subjects were screened for past history of any diseases, allergies, menstrual irregularities and bowel movement. The data related to medical history of the selected subjects are shown in Table XIII.

Table XIII. Medical history of selected subjects

Parameter	Frequency(n=570)	Per cent
Past History of any disease	46	8
Allergies	159	28
Menstrual Irregularities	123	22
Bowel Movement	105	18

Among the selected 570 subjects, eight per cent had a history of health issues and 28 per cent of selected subjects had food related allergies, 22 per cent had menstrual irregularities and 18 per cent had problems related to bowel movement. The medical history provides details on the selected subjects health conditions. The past history of any disease is important in knowing the immunity of the person. The diet suggestions for the selected subjects were provided by considering their food allergies. The diet which can replace the supplements consumed by the selected subjects were also suggested as an attempt to opt for a healthy alternative to fill the gap of nutritional inadequacy. The selected subjects with issues with bowel movement may be due to the faulty food habits like poor consumption of dietary fibre in their daily consumption. Adequate intake of dietary fibres is highly helpful for promotion of gut health and for prevention of disease conditions.

A thorough medical history, including details on past illnesses, can reveal underlying conditions that may affect nutritional status. For instance, a history of gastrointestinal disorders can signal potential malabsorption issues. Allergies to certain foods or ingredients must be documented to prevent adverse reactions and ensure safe dietary practices. In female patients, a detailed menstrual history is essential, as amenorrhea in child-bearing aged women can indicate pregnancy, chronic infection, chronic illness, or eating disorders, all of which can impact nutritional status (Nangwasha, 2024). The present study also screened the subjects with their medical history to provide them with adequate nutritional support.

4.1.1.2. Life Style pattern

Changing to a healthy lifestyle can make a big difference in general health and wellbeing. The selected subjects can achieve major benefits in physical and emotional well-being by adopting a balanced approach to sun exposure, exercise, social interaction, leisure and recreational activities. The data for lifestyle pattern is shown in Table XIV.

Table XIV. Lifestyle Pattern of the selected subjects

Parameters		Frequency (n=570)	Per cent
Leisure and Recreation	Meditation	116	20
	Solving Puzzles	4	1
	Board games	93	16
	Swimming	66	12
	Reading	87	15
	Dancing	91	16
	Music	113	20
Games or Exercise	0 hour	41	7
	1hour	366	64
	2 hours	101	18
	3 hours	62	11
Sleep pattern	2-4 hours	316	55
	5-7 hours	32	6
	8-10 hours	222	39
Social Interaction	Family and friends	302	53
	Social gathering	92	16
	Shared activities	85	15
	Spiritual and cultural activities	91	16
Means of transport	Public	229	40
	Cycle	15	3
	Private	326	57
Sun Exposure in the morning(7am-11am)	0 hour	130	23
	1 hour	408	71
	2 hours	32	6
Social media usage	1-3 hours	309	54
	4-6 hours	211	37
	7-9 hours	50	9

The lifestyle pattern followed by an individual is crucial for keeping the person healthy. In the present study the selected subjects were provided with questions to assess their lifestyle pattern. The results depicted that the lifestyle pattern the selected subjects followed was one of the major reasons for Triple Burden of Malnutrition. The results

showed that the selected subjects involved in leisure and recreational activity to keep themselves healthy. 20 per cent of subjects liked to listen to music, 16 per cent were interested in board games and dance, 15 per cent in reading, 12 per cent engaged in swimming and one per cent in solving puzzles as leisure and recreation.

Leisure and recreation activities play a crucial role in maintaining a person's overall health and well-being. Engaging in leisure time pursuits has been linked to higher levels of life satisfaction and health benefits. Specifically, the concept of "recreation specialization" highlights how individuals progressing from general interest to high engagement in leisure activities experience positive effects on their life satisfaction and health. Moreover, self-efficacy, defined as one's confidence in controlling motivation and behaviour, has been associated with increased life satisfaction, indicating that higher self-efficacy levels can lead to improved well-being (Tian *et al.,* 2022).

The physical activity and regular exercise are important component of healthy lifestyle. Seven per cent of the selected subjects did not engage in any physical activity, 64 per cent of the selected subjects engaged in 1 hour of physical activity, 18 per cent spent for 2 hours of physical activity and 11 per cent for 3 hours of physical activity. Regular exercise included brisk walk, or cycling, can strengthen muscles, elevate mood, and improve cardiovascular health. The World Health Organization recommends that adults get 150-300 minutes of moderate aerobic activity per week, or 75-150 minutes of vigorous aerobic activity. For children and adolescents, the recommendation is an average of 60 minutes of moderate aerobic physical activity per day. (Bull *et al.,* 2020)

The sleep pattern of the selected subjects revealed that, 55 per cent of the selected subjects slept for 2-4 hours, six per cent of selected subjects slept for 5-7 hours and 39 per cent of subjects slept for 8-10 hours.

Research indicates that inadequate sleep is linked to poor dietary habits, such as increased consumption of energy-dense foods and lower intake of fruits and vegetables. For instance, a study found that young women who experienced poor sleep quality consumed more carbohydrates and less dietary fiber, which can negatively affect their nutritional status and overall well-being. Furthermore, sleep deprivation can lead to hormonal imbalances that disrupt appetite regulation, often resulting in increased cravings for unhealthy foods. Approximately 30per cent of young women report sleep disturbances, which can contribute to a vicious cycle of poor nutrition and further sleep issues (Karbasi *et al.,* 2023).

The discussions and brainstorming sessions which occurs during a social interaction in the various social activities ignites the mind and healthy interactions are positive step towards a healthy life. The results of social interaction of the selected subjects depicted that 53 per cent of selected subjects were involved in interaction with family and friends, 16 per cent in social gathering and Spiritual-cultural activities and 15 per cent in shared activities.

Strong social connections have been associated with better health habits, improved cognitive performance, reduced risk of dementia, and enhanced emotional well-being. Additionally, social interactions stimulate brain activity, improve cognitive functioning, and can help tackle degenerative diseases like dementia. Furthermore, social interaction fosters a sense of community, belonging, and support, which can lead to greater satisfaction and fulfilment in life (Orben *et al.,* 2020).

The means of transport used by the selected subjects stated that 40 per cent used public transport, three per cent used cycle and 57 per cent used private vehicles. The means of transport used by the selected subjects frequently is one of the indicators towards the amount of physical activity of the selected subjects. The mode of transportation of choice can also help to lead a better lifestyle. Choosing active means of transportation, like biking or walking, can lower the impact of carbon emissions, promote physical activity, and give a chance to engage with your environment. Making minor adjustments, such as choosing to use the stairs rather than the lift, can have a significant impact. Using public transport is linked to increased levels of physical activity since getting to and from public transport stops and stations usually requires walking or riding.

According to studies, those who utilise public transit are less likely than those who drive their own cars to be obese or sedentary. Enhancing public transportation's accessibility might encourage people to choose more active forms of transportation, which can raise physical activity levels and have positive health effects including a lower risk of developing chronic illnesses including diabetes, heart disease, and stroke, as well as some types of cancer (Brown *et al.,* 2019).

The exposure to the sun revealed that 23 per cent of the selected subjects were not exposed to sunlight on daily basis, 71 per cent of selected subjects exposed themselves to 1 hour of sun exposure and six per cent of the selected subjects got 2 hours of sun exposure.

The generation of vitamin D, which is vital for immune system and bone health, requires moderate sun exposure. Finding the ideal time is crucial, though, as is shielding your skin from damaging UV radiation (Santana *et al.,* 2022).

The result on social media usage showed that 54 per cent of the selected subjects were indulged in social media usage for 1-3 hours, 37 per cent for 4-6 hours and 9 per cent for 7-9 hours. The usage of social media draws the selected the subjects and incline them to their homes and prevent them from any kind of games. The regular usage of social media for a longer time will affect subjects mentally and physically.

The influence of social media on the nutritional status of young women is significant, as it can adversely affect body image and eating behaviours. Research indicates that excessive social media use, particularly among young women, is linked to higher levels of body dissatisfaction and unhealthy dieting practices. For instance, a systematic review found that social media engagement is associated with increased dieting behaviours and emotional eating, with young women spending more than two hours per day on these platforms showing higher scores in disordered eating assessments (Rounsefell *et al.,* 2020).

Phase-II

4.2.Nutritional status of the selected subjects

4.2.1.Anthropometric Measurements

Anthropometric measurement is a determinant of health status of an individual. It is also an outcome of the food consumed by the selected subjects. The anthropometric measurements are used to categorise the selected subjects in to categories of malnutrition in terms of under nutrition, over nutrition and normal nutrition. Anthropometric measurements (i.e.) height, weight, waist and hip circumference are also used to compute Body Mass Index (BMI) and Waist to Hip Ratio (WHR). Anthropometric measurements of all the selected subjects (n= 570) were recorded and presented in the following paragraphs.

4.2.1.1.Height

The height along with weight determines the BMI of the selected subjects. India's malnutrition profile is fast shifting, with improvements being made on many under-nutrition indicators and a sharp rise in overweight and obesity rates, particularly in the young adult population. Apart from the dual burden of malnutrition, India has made relatively little headway in addressing the huge health disparities that exist between socioeconomic

categories and residential locations. The coexistence of growing overweight and obesity rates and under nutrition indicates that India has to create new nutrition policies that give priority to dual-purpose behaviours (Nguyen *et al.,* 2021). Height of the selected subjects (n=570) recorded are as in Table XV.

Table XV. Height Distribution of the selected subjects

Range(cm)*	Frequency(n=570)	Per cent	Mean ±SD*
140-149.9	208	37	154.83±5.45
150-159.9	263	46	
160-169.9	99	17	

*ICMR NIN (2020)

The height of the selected 570 subjects were recorded and the results showed that 37 per cent of the selected subjects were in the height range of 140-149.9cm, 46 per cent were in the range of 150-159.9 cm and 17 per cent were in the range of 160-169.9cm. The mean height of the selected subjects for this study was 154.83±5.45 which is less than 162cm, the standard height women recommended by ICMR NIN (2020).

4.2.1.2.Weight

Weight of the selected subjects plays an important role in determining the nutritional status and factors determining the lifestyle diseases. The cohabitation of anaemia, overweight, and obesity in this urban population subset makes to measure for addressing socioeconomic inequality and under nutrition as well as overweight/ obesity and under nutrition necessary (Sethi *et al.,* 2020). Table XVI depicted the distribution of weight of the selected subjects (n=570).

Table XVI. Weight Distribution of the selected subjects

Range(kg)*	Frequency(n=570)	Per cent	Mean ±SD*
40-50	103	18	57.35±11.09
50.1-60	238	42	
60.1-70	168	29	
70.1-80	61	11	

*ICMR NIN (2020)

The result of the study where the selected subjects were recorded for their weight depicted that 18 per cent of the selected subjects were in the weight range of 40-50 kg, 42 per cent of the selected subjects were in the weight range of 50.1-60 kg, 29 per cent of the selected subjects were in the weight range of 60.1-70 kg and 11 per cent of the selected subjects were in the weight range of 70.1-80 kg. The mean weight for (n=570) selected subjects was 57.35±11.09 which is more than the standard weight of 55kg, recommended by ICMR NIN (2020).

4.2.1.3.BMI

Body Mass Index (BMI) is the combination of height in m^2 and weight in Kg. BMI plays a key role in classifying the selected subjects in to Dual Burden of Malnutrition (i.e.) under-weight and over-weight. BMI of the selected subjects are shown in Table XVII.

Table XVII. BMI Distribution of the selected subjects

Grades of Malnutrition*	Range of BMI	Frequency (n=570)	Per cent
Underweight	Less than 18.5	394	69
Normal Weight	18.5-24.9	70	12
Overweight	25.0-29.9	81	14
Obesity Grade I	30.0-34.9	20	4
Obesity Grade II	35.0-39.9	5	1
Obesity Grade III	≥40.0	0	0

*WHO (2020)

Table XVII shows that 69 per cent of the selected subjects were underweight with less than 18.5 BMI, 12 per cent of the selected subjects were in the range of 18.5-24.9 who were normal with their BMI, 14 per cent were in the category of over-weight who were in the range of 25-29.9 BMI, four per cent of the selected subjects were in the range of 30-34.9 BMI range who were in the category of Obesity grade I, meagre (one) per cent of the selected subjects were in the range of 35-39.9 BMI range who are among grade II obesity and none of the subjects were in the grade III obesity which is in the range of more than 40 BMI. The increase in BMI plays a pivotal role in the occurrence of majority of the lifestyle

related health issues. A proper adherence to diet plan and regular exercise is very much important to prevent the onset of lifestyle diseases. The low BMI of the selected subjects depicted the under-nourishment status of an individual and therefore the morbidity rate of the country is rising up as this group of young adult women makes up most of the population.

In a research study by Prausmüller *et al.,* (2022) stated that when compared to their well-nourished peers, obese subjects experiencing malnutrition have a significantly bad result. Malnutrition significantly alters the trajectory of the outcome with relation to BMI.

Research has shown that underweight women face increased risks of complications during pregnancy and childbirth, while overweight women are at higher risk for chronic diseases such as cardiovascular issues and diabetes. Furthermore, the prevalence of underweight among women remains a significant public health concern, particularly in low- and middle-income countries, where socio-economic factors greatly influence nutritional status. By utilizing BMI as a screening tool, researchers and healthcare providers can better understand the nutritional challenges facing women and implement targeted interventions to improve health outcomes and reduce malnutrition rates in this vulnerable population (Budzyński and Szukay, 2022).

4.2.1.4.Measurements of hip and waist circumference and computation of Waist to Hip Ratio (WHR)

The Circumference Measurement are of different types. Waist to Hip ratio (WHR) is one among the different types of circumference measurements. Waist to Hip Ratio is a computation of both waist and hip circumference of the selected subjects and used to grade under-weight and over-weight. This ratio categorises the selected subjects in to under-weight and over-weight.

The Waist-to-Hip Ratio (WHR) is a measure of fat distribution in the body, calculated by dividing the waist circumference by the hip circumference. A higher WHR, indicating more weight around the waist and associated with an increased risk of lifestyle-related diseases. Ideally, women should have a WHR of 0.85 or less, while men should aim for a WHR of 0.95 or less (WHO 2020). Table XVIII depicts the result of WHR of the selected subjects.

Table XVIII. WHR Distribution of the selected subjects

Range*	Frequency(n=570)	Per cent	Mean ±SD
0.70-0.75	77	14	0.768±0.027
0.76-0.80	214	37	
0.81-0.85	99	17	
0.85-0.9	180	32	

*WHO (2020)

Table XVIII shows the results of WHR that 14 per cent of the selected subjects were in the range of 0.7-0.75, 37 per cent of the selected subjects were in the range of 0.76-0.8, 17 per cent were in the range of 0.81-0.85 and 32 per cent were in the range of WHR 0.85-0.9. It is interesting to note that the mean of WHR was 0.768±0.027 and the normal range of WHR for women is less than 0.85.

Studies have shown that women with a high WHR may experience adverse health outcomes even if their overall BMI is within a normal range, highlighting the importance of considering both metrics in nutritional assessments. Furthermore, understanding WHR can aid in identifying those at risk of the double burden of malnutrition, where individuals may experience both under nutrition and overweight/obesity simultaneously (Hasan *et al.,* 2022).

4.2.2.Biochemical Profile

Biochemical profile of the selected subjects was carried out exclusively to find the micro-nutrient deficiencies in the young adult women. Blood samples were collected from 570 selected subjects and tested to estimate serum calcium and Haemoglobin level of the selected subjects considering for screening test. The selected subjects with low Haemoglobin (n=214) were further examined for serum iron and serum folic acid. The results for the biochemical estimation are shown in Table XIX.

Table XIX. Biochemical Profile of the selected subjects

Parameter	Normal Range	Range	Frequency(n=570)	Per cent
Haemoglobin(g/dl)	12-15	9.9-10.7	214	37
Serum calcium(mg/dl)	8.7-11	7.5-8	76	16
		8.1-8.6	14	

Assessment of subjects with low Haemoglobin	Normal Range	Range	Frequency (n=214)	Per cent
Serum Folic Acid(ng/ml)	4.8-37.3	2-4	114	53
Serum Iron(µg/dl)	50-170	30-50	100	47

Out of 570 selected subjects, 214 subjects (37 per cent) had low haemoglobin level of less than the normal range (i.e.) 12g/dl. 16 per cent of the subjects had serum calcium in the range of 8 to 10 mg where the normal range of serum calcium is 8.7-11 mg/dl. The subjects with low Haemoglobin (i.e.) 214 subjects were further subjected for estimation of serum folic acid and serum iron.

In a study by Singh *et al.,* (2017) involving women aged 15-35, the median serum folate level was found to be 2.5 ng/ml, indicating that many women were below the recommended cut-off for adequate folate levels, which is a significant concern given the role of folate in preventing anaemia and supporting reproductive health. The high prevalence of folate deficiency in malnourished women underscores the need for targeted nutritional interventions to improve health outcomes in this population. In the present study, 53 per cent of the selected subjects had folic acid level ranging from 2-4ng/dl where the normal range is 4.8-37.3 ng/dl.

Studies indicate that approximately 40per cent of young women aged 12 to 21 may experience iron deficiency, with higher rates observed in those from minority and low-income backgrounds. Regular monitoring of serum iron levels can help identify deficiencies

early, allowing for dietary changes or supplementation to improve iron status and prevent the adverse health effects associated with low iron levels (Al-Naseem *et al.,* 2021). In the present study, 47 per cent of selected subjects had low serum iron content in their blood (i.e.) 30-50 µg/dl, where the normal range of Serum Iron is 50-170 µg/dl.

Studies among Indian women over 25 years of age have reported the prevalence of osteoporosis to be between 8 per cent to 62 per cent. This wide range highlights the substantial impact of calcium deficiency on bone health in this population. A retrospective study in India found that 54.3 per cent of women were osteoporotic, 26.5 per cent were osteopenic, and 19.1 per cent had normal bone mineral density. There was a significant positive correlation between bone mineral density and serum vitamin D and calcium levels, emphasizing the importance of adequate calcium intake for bone health (Shlisky *et al.,* 2022) (Di Cairano, *et al.,* 2022). The present study had prevalence for calcium deficiency of 16 per cent.

4.2.3.Clinical Examination

One of techniques of ABCD technique for nutritional assessment is the clinical examination. The selected subjects were examined for their physical appearance with the signs and symptoms of any nutritional deficiencies. The selected subjects were provided with questionnaire and were asked to mark for any signs and symptoms experienced during the study period. Data related to clinical examination are shown in Table XX.

Table XX. Clinical Profile of the selected subjects

Signs and Symptoms experienced	Frequency(n=570)	Per cent
Pallor (Conjunctiva, Palms, Nail Beds, Tongue)	23	4
Fatigue	81	14
Visual problems	67	12
Hair Loss	171	30
Headache	308	54
Brittle nails	36	6
Dry scaly skin	78	14

Among the selected subjects of 570, the Clinical profiling was used to examine the subjects with various signs and symptoms of nutritional deficiencies. The signs and symptoms in the selected subjects were examined to assess these nutritional deficiencies. Four per cent of the selected subjects experienced the signs and symptoms of pallor, 14 per cent of selected subjects experienced fatigue, 12 per cent of the selected subjects had visual problems, 30 per cent of the selected subjects had hair loss issues, 54 per cent of selected subjects had regular headache, 6 per cent had brittle nails and 14 per cent had dry scaly skin. None of the selected subjects had any issues with breathlessness, palpitation, bitot spot and bleeding gums. The selected subjects with fatigue and menstrual irregularities had the most important signs of Iron deficiency anaemia.

In a study conducted by Owais *et al.,* (2021) and Osborn *et al.,* (2021) stated that low iron levels, particularly in the form of iron deficiency anaemia, can lead to various complications for women. These complications include fatigue, weakness, impaired cognitive function, increased risk of preterm birth and low birth weight, reduced immune function, restless leg syndrome, and pica, which involves unusual cravings for non-food items like ice or dirt. Iron deficiency anaemia can significantly impact a woman's quality of life, energy levels, and overall health, making it crucial for women, especially those of reproductive age and during pregnancy, to maintain adequate iron levels through a balanced diet or supplementation to prevent these complications.

4.2.4.Quantitative Dietary Intake

4.2.4.1.Dietary Intake

The dietary intake of the selected subjects plays a vital role in deciding the nutrient intake. Understanding the importance of dietary intake and the five food groups is crucial for maintaining a healthy lifestyle. By including each food group into our daily meals, we can ensure that our bodies receive the essential nutrients needed to function optimally. The five food groups – cereals and millets, pulse and legumes, fruits and vegetables, milk and meat products, fat and sugars- holistically provide a balanced diet to promote overall health and well-being by including a diverse range of foods from these groups in our meals. Exploring the significance of each food group to fulfil the nutritional needs and requirements of an individual to support the health goals and lead a more fulfilling lifestyle. It is essential to prioritize a balanced diet including foods from all five groups and is highlighted in Table XXI.

Table XXI. Dietary Intake of selected subjects

Attributes		Frequency (n=570)	Per cent
Type of Diet	Vegetarian	136	24
	Non vegetarian	269	47
	Vegan	51	9
	Ovo-vegetarian	114	20
Frequency of Diet Variation	Everyday	271	48
	Sometimes in a week	169	30
	Weekends	130	22
Frequency of daily meal consumption	1	11	2
	2	244	43
	3	169	30
	4	114	20
	5	32	5
Frequent consumption of beverages/drinks	Tea	192	34
	Milk	110	19
	Coffee	89	16
	Health drinks	87	15
	Fruit juice	92	16
Factors influencing food consumption	Availability of Food	182	32
	Binge Eating	65	11
	Weight conscious	94	17
	PMS (Pre-Menstrual Syndrome)	161	28
	Stress	68	12

The selected subjects were provided with a questionnaire consisting of various questions related to quality and quantity of food in terms of nutrients in their daily food consumption pattern. The result of dietary intake is depicted in Table XXI and expressed that 24 per cent of selected subjects followed a vegetarian diet, 47 per cent followed non-vegetarian diet, nine per cent of the consumed vegan diet and 20 per cent of the consumed ovo-vegetarian diet. The quality of food is vital for a healthy life. Malnutrition is also caused due to lack of quality food rather than quantity of the foods consumed.

Frequency and types of diet was related to diet variation and revealed that 48 per cent of the selected subjects had variety in diet every day, 30 per cent of the selected subjects had diet variety in diet sometimes in a week and 22 per cent of selected subjects had variety in diet only on weekends. The monotonous diet which they consumed leads to an aversion towards food and this in turn leads to malnutrition. The variation in diet is very much important to eliminate the monotony in food. The more variety in food pattern, the more is the food consumption in an appropriate quantity.

The aversion towards food and eating disorders can be prevented to a greater extend by bringing out variety in foods. The results related to meals consumed in a day showed that two per cent of the selected subjects consumed only one meal a day, 43 per cent of the selected subjects consumed two meals per day, 30 per cent of the selected subjects consumed three meals a day, 20 per cent consumed four meals a day and five per cent of selected subjects consumed five meals a day. There is a relation between number of meals consumed and malnutrition. Food availability and accessibility are prime importance to eradicate malnutrition. Current trend of malnutrition in young adult women is not driven by poor availability and accessibility towards food but more due to diet and consumption of junk foods.

The result related to consumption of beverages showed that, 34 per cent of the selected subjects consumed tea, 19 per cent of the selected subjects consumed milk, 16 per cent of selected subjects consumed coffee, 15 per cent of the selected subjects consumed health drinks and 16 per cent of the selected subjects consumed fruit juice every day.

Factors that influenced the food consumption were also assessed and the results pointed out that 32 per cent of the selected subjects consumed diet due to the availability of food, 11 per cent of the selected subjects consumed food due binge eating, 17 per cent of the selected subjects consumed food due to weight consciousness, 28 per cent of the selected

subjects consumed food due to PMS and 12 per cent consumed food due to psychological problem in terms of stress. The consumption of food due to PMS is an alarming cause for weight gain as the subjects are not consciously consuming food. This can lead to more health issues. These factors are important in deciding the food consumption pattern of the selected subjects. Binge eating which is an eating disorder is one of the factors contributing towards improper eating pattern.

4.2.4.2.24 hour recall

Dietary recall, particularly the 24-hour dietary recall method, plays a crucial role in nutrition studies for several reasons. It provides detailed and quantitative information on individual diets by capturing all foods and beverages consumed within a specific period, typically the past 24 hours. This method allows researchers to assess total dietary intake, nutrient intake, dietary patterns, and food groups consumed, offering a comprehensive understanding of an individual's nutritional habits and potential deficiencies. By analysing dietary recalls, researchers can identify trends, assess nutrient adequacy, and tailor interventions to improve dietary quality and overall health outcomes. Additionally, dietary recall data can be used to examine relationships between diet and health variables, making it a valuable tool in understanding the impact of nutrition on various health conditions and informing public health policies and interventions (John *et al.,* 2020).

24-hour recall is another method used under dietary assessment to predict the need for nutritional adequacy. The 24-hour recall method was used to collect the dietary pattern of the selected 570 subjects where they were provided with a questionnaire and requested to mention their daily intake of food (i.e.) 24-hour a day. They were provided with a table in which the food they consumed, its ingredients and quantity need to be mentioned. The mention of the ingredients was important to check the quality of food consumed by the selected subjects. The quantity of food represents the nutrient adequacy of the diet. 24-hour recall also helped to categorise the selected subjects into different grade of malnutrition. Based on the 24-hour recall method, nutrients were calculated using diet soft software and given in Table XXII with ICMR-RDA (2020).

Table XXII. Nutrient Calculation based on 24-hour recall of the selected subjects

Nutrients	Mean±SD	ICMR RDA for Sedentary working Women (2020)	Excess/Deficient
Energy(Kcal)	1846.71±271.28	1645	+201.7
Carbohydrate(g)	157.15±33.84	130	+27.15
Protein(g)	53.28±25.98	45.7	+7.58
Fat(g)	36.53±10.67	20	+17
Calcium(mg)	613.06±283.96	1000	-386.94
Iron(mg)	18.14±5.92	29	-10.86
Folic Acid(µg)	150.49±35.23	220	-70
Vitamin C(mg)	36.23±15.83	65	-29
Vitamin A (µg)	480.74±210.94	840	-359.26
Dietary Fibre(g)	10.07±11.88	25	-15

The Table XXII shows the mean intake of the selected subjects in the age group of 18-21 years for Energy, Protein, Fat, Calcium, Iron, Folic Acid, Vitamin C, Vitamin A and dietary fibre. The values were 1846.71 Kcal ±271.28 for energy, 157.15 g ±33.84 for carbohydrates 53.28 g ±25.98 for protein, 36.53 g ±10.67 for fat, 613.06 mg ±283.96 for calcium, 18.14 mg ±5.92 for iron, 150.49 µg ±35.23 for folic acid, 36.23 mg ±15.83 for Vitamin C, 480.74 µg ±210.94 for Vitamin A and 10.07 g ±11.88 for dietary fibre. The selected subjects were found to consume excess energy with 201.7 Kcal, carbohydrates with 27.15 g, protein with 7.58g and fat with 17g. The selected subjects were also in deficient condition and was found to be Iron with 10.86 mg, Calcium with 386.94 mg, Folic acid with 70µg, Vitamin A by 359.26 µg, Vitamin C by 29mg and Fibre with 15g. The collected data revealed that the surplus consumption of macro nutrients and deficient consumption of micronutrients were the factors for the occurrence of the condition of over nutrition and deficient conditions and precipitated to cause micronutrient deficiencies.

4.2.4.3.Food Frequency Questionnaire (FFQ)

The food frequency questionnaire (FFQ) was provided to the selected subjects and were informed to mark the frequency of the food items consumed by the selected subjects. The food frequency point out all the food items mentioned in the Indian Food Composition Table (IFCT) (2020). The food frequency questionnaire mentioned the foods that are locally available and regionally consumed. The foods that are available during the time of the research study period was also mentioned. The selected subjects were provided with five columns which indicated the frequency of food consumption in terms of daily, weekly, monthly, occasionally and never. The frequency of consumption of the food pattern of the selected subjects mentioned in the questionnaire were assessed. The data of the food frequency questionnaire is mentioned in Table XXIII.

Table XXIII. Frequency of food consumption pattern of the selected subjects

Cereals and Millets (per cent)					
Food Item	**Daily**	**Weekly**	**Monthly**	**Occasionally**	**Never**
Rice	86	14	0	0	0
Rice flakes	1	2	4	93	0
Puffed Rice	0	1	14	85	0
Wheat	17	53	13	17	0
Ragi	1	6	11	82	0
Bajra	0	0	0	77	23
Vermicelli	0	11	41	34	15
Semolina	0	37	29	19	14
Refined wheat flour/ Maida	0	12	58	29	0
Pulses and Legumes (per cent)					
Food Item	**Daily**	**Weekly**	**Monthly**	**Occasionally**	**Never**
Bengal Gram Whole	16	37	34	12	0
Green gram Whole	18	20	43	19	1
Cow pea	0	1	7	85	7
Rajmah	0	0	11	53	36
Soyabean	0	32	40	20	8
Green peas	0	4	26	70	1
Horse gram	0	2	21	56	21

Green leafy Vegetables (per cent)					
Food Item	**Daily**	**Weekly**	**Monthly**	**Occasionally**	**Never**
Amaranths	0	0	1	76	24
Drumstick leaves	0	17	47	23	12
Spinach leaves	0	3	30	67	0
Fenugreek leaves	0	1	20	38	41
Mint leaves	0	0	33	65	1
Cabbage	0	15	11	68	6
Other Vegetables (per cent)					
Food Item	**Daily**	**Weekly**	**Monthly**	**Occasionally**	**Never**
Ash Gourd	0	3	12	73	12
Snake Gourd	0	7	32	54	7
Bitter Gourd	0	1	17	64	18
Drumstick	0	2	35	52	11
Cauliflower	0	31	38	18	13
Cluster beans	0	56	29	14	1
Carrot	15	27	37	21	0
Potato	0	38	43	17	2
Cabbage	0	18	54	17	11
Brinjal	0	10	15	51	24
Ladies finger	0	22	42	36	0
Raddish	0	0	31	35	34
Sweet potato	0	0	0	60	40
Tapioca	0	0	16	69	15
Yam	0	14	20	53	13
Colocasia	0	0	22	36	42
Plantain	0	4	15	81	0
Beetroot	2	18	25	21	34
Cucumber	6	28	40	25	1

Fruits (per cent)					
Food Item	**Daily**	**Weekly**	**Monthly**	**Occasionally**	**Never**
Apple	1	2	14	83	0
Papaya	0	0	1	92	7
Orange	0	0	7	92	0
Banana	29	51	20	0	0
Watermelon	0	0	2	95	3
Guava	0	1	1	82	16
Strawberry	0	0	2	89	8
Pomegranate	1	22	54	10	13
Custard Apple	0	0	0	92	8
Pineapple	0	6	14	43	37
Grapes	3	14	27	56	0
Sapota	0	15	39	14	32
Musk melon	0	0	1	96	3
Dates	56	34	10	0	0
Raisins	34	10	38	17	1
Dry Fig	2	8	9	61	19

Milk and Milk Products (per cent)					
Food Item	**Daily**	**Weekly**	**Monthly**	**Occasionally**	**Never**
Paneer	0	15	24	34	26
Milk	76	11	2	0	11
Cheese	1	2	40	53	4
Curd	78	12	6	0	4

Poultry and Flesh foods (per cent)					
Food Item	**Daily**	**Weekly**	**Monthly**	**Occasionally**	**Never**
Fish	0	5	6	74	16
Meat	0	15	36	36	13
Egg	19	26	36	4	15
Sugars (per cent)					
Food Item	**Daily**	**Weekly**	**Monthly**	**Occasionally**	**Never**
Sugar	70	18	0	0	12
Jaggery	1	1	2	83	13

The results showed that most of the selected subjects consumed rice regularly (86 per cent) as a part of their daily menu planning. 93 per cent of the selected subjects consumed rice flakes occasionally. Puffed rice was consumed occasionally by 85 per cent of the selected subjects. Wheat was consumed daily by 17 per cent of the selected subjects. Ragi, which is a good source of calcium was consumed daily only by one per cent of the selected subjects. Bajra which is a millet and has many nutritional properties was consumed by 77 per cent of the selected subjects occasionally. 41 per cent of the selected subjects consumed vermicelli monthly. Semolina was consumed weekly by 37 per cent of the selected subjects. Refined wheat flour which is the major cause for many lifestyle diseases was consumed daily by weekly by 12 per cent of the selected subjects. 58 per cent of the selected subjects consumed refined flour monthly.

In ICMR Food Groups, the pulses and legumes were covered as 2nd food group. 16 per cent of the selected subjects consumed Bengal gram whole daily. Bengal gram (whole) is a good source of folic acid and consumption of spouted form of this pulse will enrich the Vitamin C and high fibre content in the sprouted Bengal gram and if consumed whole prevents constipation. One per cent of the selected 570 subjects never consumed green gram (whole) which is another good source of folic acid. Sprouted form of green gram is the most commonly available and affordable pulse for the common person. Horse gram is one of the rich sources of iron and was never consumed by 21 per cent of the selected subjects. Horse gram provides instant energy and appreciable amount of dietary fibre.

Green leafy vegetables are hardly consumed by the selected subjects daily. They are good source of ß carotene. 24 per cent of the selected subjects never consumed amaranth leaves. Only 17 per cent of the selected subjects consumed drumstick leaves weekly. Due to the bitter taste, 41 per cent of the selected subjects never had fenugreek leaves. Only one per cent of the selected subjects had mint leaves weekly once. Cabbage was consumed by 68 per cent of selected subjects occasionally in their routine dietary pattern.

Most of the squash family were under consumed by the selected subjects due to the poor taste of these vegetables. Only three per cent of the selected subjects had ash gourd on weekly basis, 18 per cent of the selected subjects never consumed bitter gourd, 52 per cent of the selected subjects had drumstick occasionally. 38 per cent of the selected subjects had cauliflower monthly, 56 per cent of the selected subjects consumed cluster beans weekly, 15 per cent of the selected subjects consumed carrot daily. Potato which is one of the rich contributors of carbohydrates was consumed weekly once by 38 per cent of the selected subjects. Only 10 per cent of the selected subjects consumed Brinjal weekly once. Due to the allergy caused by the brinjal, people have an aversion towards brinjal and 42 per cent of the selected subjects consumed ladies' finger on monthly basis. Due to the pungent smell of radish, 34 per cent of the selected subjects never consumed radish, 60 per cent of the selected subjects consumed sweet potato occasionally which is also a good contributor of carbohydrates. Yam and Colocasia were not widely accepted among the selected subjects due to its texture. 81 per cent of the selected subjects consumed plantain occasionally. Only two per cent of the selected subjects consumed beetroot daily which is a good source of non-haem iron. Only six per cent of the selected subjects consumed cucumber daily which is known to act as a cooling agent to our gastro-intestinal tract.

The results for consumption of Fruits groups showed that 83 per cent of the selected subjects consumed apple occasionally, 92 per cent consumed papaya occasionally, 95 per cent of selected subjects consumed orange occasionally, 29 per cent of selected subjects consumed banana daily, 95 per cent of the selected subjects consumed watermelon occasionally and 82 per cent of selected subjects consumed guava occasionally. Only one per cent of the selected subjects consumed pomegranate in their daily dietaries. Most of the fruits were consumed occasionally. Dates which is taken to improve the haemoglobin count and to prevent iron deficiency anaemia were consumed on a daily basis by 56 per cent of the selected subjects. Raisins are also consumed by 34 per cent of the selected subjects daily.

Dry fig, ground nuts, cashew nuts and almonds were consumed by the selected subjects on daily basis by 2 per cent, 1 per cent, 14 per cent and 15 per cent respectively.

Among the foods that cause food allergies, mushrooms are occasionally consumed by 74 per cent of the selected subjects. Of the selected subjects, 74 per cent occasionally consumed meat and 36 per cent occasionally had fish. Among the selected subjects, 26 per cent consumed eggs once in a week. 36 per cent of the selected subjects reported that they consumed meat monthly once in their routine diet.

Milk was consumed by 76 per cent of the selected subjects daily. 26 per cent of selected subjects never consumed Paneer which a good source of calcium, 78 per cent of the selected subjects consumed curd on daily basis, which is a good source of protein and calcium, 53 per cent of the selected subjects consumed cheese occasionally to meet their protein requirements. Only one per cent of selected subjects consumed jaggery on daily basis which is a healthy alternative for sugar for enhancing the sweet taste of their routine beverages.

Among various macronutrients, protein plays a vital role in muscular formation and promotion of health. Protein intake recommendation for young women vary based on factors like age, physical activity levels, and overall health. The general Recommended Dietary Allowance (RDA) for protein is about 46 grams per day for adult women, with an increase to 71 grams per day during pregnancy or breastfeeding. For young women aged 14-18 years, the RDA is around 46 grams per day. It is important to note that protein requirements can differ for individuals based on their specific needs and circumstances (Wolfe *et al.,* 2017).

In the current study the selected subjects has a mean consumption value of 53.28g/day for protein. The protein intake is sufficient according to the ICMR RDA (2020). The results of FFQ in the current study depicts a poor intake of quality proteins. The results of 24-hour recall records that the selected subjects have adequate protein intake. In all these, the quantity of protein requirement is being met but quality of protein has been sacrificed. Pulses, Milk products, Poultry and Flesh products and Nuts are the food groups, among the five food groups of the ICMR classification, which provides with quality protein. Among the above-mentioned food groups, egg is categorized as complete protein with all essential amino acids. Meat and milk products e.g. Paneer provide with a quality protein. Only 16 per cent of selected subjects consumed Bengal gram daily. 36 per cent of selected subjects

never consumed Rajmah which is a good source of protein. Only 19 per cent of the selected 570 subjects consumed egg daily. 26 per cent of the selected subjects never consumed paneer. 13 per cent of the selected subjects never consumed meat. The low protein consumption of by the selected subjects in the present study is one of the major factors for being predisposed to Triple Burden of Malnutrition. The clinical symptoms like Pallor, Hair loss, Menstrual Irregularities are caused by poor protein intake in the food consumption pattern.

4.2.5.Triple Burden of Malnutrition among the selected subjects

The triple burden of malnutrition (TBM) in young adult women refers to the coexistence of over-nutrition, under-nutrition, and micronutrient deficiencies. The deficiencies that commonly exists in the current scenario are iron deficiency anaemia, calcium deficiency and folic acid deficiency.

Table XXIV depicts the occurrence of Triple Burden of Malnutrition in young adult women selected for the present study.

Table XXIV. Profile of Triple Burden of Malnutrition among the selected subjects

Triple Burden of Malnutrition	Frequency(n=570)	Per cent
Subjects with Normal BMI		
• without Micronutrient deficiency	**70**	**11**
• with Micronutrient deficiency	Nil	0
Under - weight Subjects		
• without Micronutrient deficiency	**90**	**16**
• with Micronutrient deficiency	**226**	**40**
➢ Iron	100	18
➢ Calcium	90	16
➢ Folic Acid	36	6
Over-weight Subjects		
• without Micronutrient deficiency	**106**	**19**
• with Micronutrient deficiency (Folic Acid)	**78**	**14**

The Table XXIV depicts the data of selected subjects with Triple Burden of Malnutrition. All the 570 subjects were subjected to anthropometric measurements (i.e.)

height, weight, waist circumference, hip circumference and computation of BMI and WHR to assess the grade of malnutrition.

As part of the biochemical profiling, total of 570 subjects were screened for Haemoglobin and Serum Calcium. The subjects with low Haemoglobin (n=214) in screening test were further tested for serum iron and serum folic acid. The result depicted that 11 per cent of the selected subjects out of 570 were with normal BMI and WHR.

Among the 570 subjects, there were 16 per cent of selected subjects who were under-weight without any micronutrient deficiencies. 40 per cent of selected subjects were under-weight with micronutrient deficiencies. Out of the 40 per cent of selected subjects who were under-weight with micronutrient deficiencies, 18 per cent were with low serum iron, 16 per cent with low serum calcium and 6 per cent with low serum folic acid. Among the 570 subjects, 19 per cent of selected subjects were over-weight without any micronutrient deficiencies. 14 per cent of the selected subjects were over- weight with micronutrient deficiencies (i.e.) folic acid.

Phase-III

4.3.Formulation and Evaluation of Dietary supplements and Nutrition Education modules for Nutrition Interventions for Triple Burden of Malnutrition

4.3.1.Formulation and Evaluation of Nutrition Education modules

The Formulation and Evaluation of Dietary Supplements and Nutrition Education modules for Triple Burden of Malnutrition was executed and were discussed in phases in the following paragraphs. Nutritional Education and Nutritional Supplementation were carried out systematically. The selected subjects enthusiastically participated during the study period of three months. The education period ended with a practical class where the selected subjects were grouped into different groups. They prepared diets for various conditions with special reference to overweight, obesity and under nutrition and deficiency condition of vitamin and minerals and also prepared diet for cardiovascular disease and diabetic Mellitus.

Nutritional awareness was provided to both Experimental and Control groups. The effect of Nutritional Education modules on nutrition health knowledge were evaluated using a KAP (Knowledge, Attitude and Practice) study. Nutrition Education modules were provided to 250 selected subjects in Experimental group for three months. The control group which consisted of 250 selected subjects were provided only nutritional awareness before

the Nutrition Intervention period. The Experimental group and control group were provided with a questionnaire which contained 30 questions. Thirty questions were divided under heads of Knowledge, Attitude and Practice of 10 questions each and were provided to both Experimental and control group, pre and post the nutrition interventions. The questions in each session were framed to assimilate the maximum output of their knowledge, attitude and practices among the selected study subjects.

In a study conducted by Keats *et al.,* (2021) it was established that nutrition interventions play a crucial role in combating malnutrition which disproportionately affects women due to biological factors. By targeting the gender nutrition gap through programs that empower women, these interventions aim to improve the nutritional status of women and girls. Investing in nutrition not only directly impacts women's health but also breaks the intergenerational cycle of malnutrition, as malnourished mothers are more likely to give birth to malnourished babies. These interventions not only have the potential to improve individual health outcomes but also contribute to broader societal development and prosperity by ensuring healthier generations and reducing the burden of malnutrition across communities.

4.3.2.Formulation and Evaluation of the Dietary Supplements

4.3.2.1.Sensory Evaluation of Dietary Supplements

The selected experimental group subjects (n=250) were provided with three dietary supplements pertaining to different nutritional deficiencies. The ingredients used in the development of the dietary supplements were selected to meet the nutritional requirements of the selected subjects in the three category of malnutrition and given in Table XXV.

Table XXV. Dietary Supplements to meet the nutritional requirements

Dietary Supplements	Beneficiaries	Quantity used for supplementation (g)	No: of selected subjects in experimental group (n=250)	Per cent
Ragi Brownie	Calcium deficient subjects	100	45	8
Sprouts Tikki	Folic Acid deficiency and Over-weight subjects	100	110	19
Nutri Ball	Under weight and Iron deficiency subjects	100	95	17

The results in Table XXV depicted the developed nutrient supplements, serving quantity used for supplementation and the number of selected subjects in the experimental group. The supplementation was carried out for five days a week for 90 days. The Ragi Brownie was developed to benefit the selected subjects with Calcium deficiency of normal body weight and 100 g of Ragi Brownie was provided to 45 selected subjects. 100g of Sprouts Tikki was supplemented to a total number of 110 selected subjects with Folic acid and Over-weight in which selected 57 subjects were Folic acid deficient and selected 53 subjects with Over-weight. 100g of Nutri Ball was supplemented to a total number of 95 subjects with iron deficiency and under-weight in which the selected 45 subjects were with under-weight and selected 50 subjects with iron deficiency.

Sensory evaluation analyses the developed products on different aspects of colour, texture, appearance, taste, flavour, and overall acceptability and provides insights on the factors that contribute to the selected subjects' perception of a food products intended for supplementation. The sensory evaluation was performed by 30 semi-trained panel members.

4.3.2.1.1.Sprouts Tikki

Three variations of Sprouts Tikki were assessed for sensory evaluation. Table XXVI shows the results of One-Way -ANOVA for sensory evaluation score of Sprouts Tikki. Figure 5 shows the Radar Graph for sensory evaluation of Sprouts Tikki.

Table XXVI. Statistical Analysis of Sensory Evaluation of Sprouts Tikki

Variations	Mean ± Standard Deviation	F value	p-value
ST1	7.0333 ± 1.12903	4.037	0.021
ST2	4.8667 ± 1.43198		
ST3	4.6000 ± 1.30252		

The One-Way ANOVA analysis showed that the p-value is 0.021 which is less than 0.05. Therefore, there is a significant difference in the overall acceptability between the three variations of Sprouts Tikki. The mean value for ST1 is 7.0333 ± 1.12903, ST2 is

4.8667 ± 1.43198 and ST3 was 4.6000 ± 1.30252. Therefore, the Sprouts Tikki variation ST1 was the highly accepted variation and considered for dietary intervention.

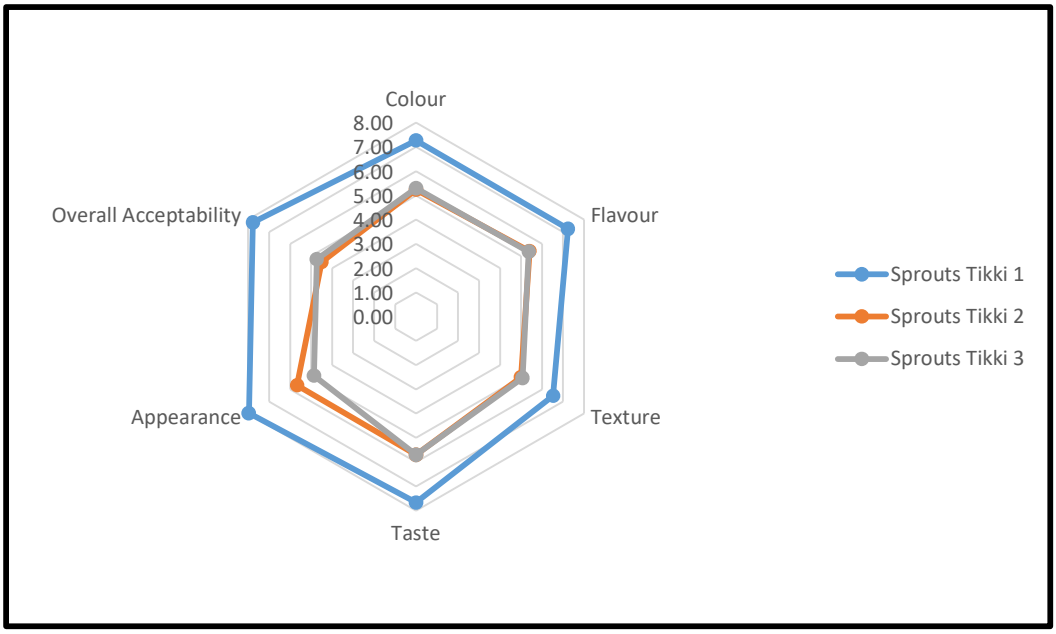

Figure 5. Radar graph for Sensory Evaluation of Sprouts Tikki

The Radar graph showed that the average score for colour for ST1 was 7.27 followed by ST2 and ST3 with an average score of 5.23 and 5.3 respectively. Flavour of ST1 was rated among the highest with an average rating of 7.23 followed by 5.40 for ST2 followed by 5.37 of ST3. Texture for ST1 was the highest rated variation with an average rating of 6.53 followed by 5.00 and 5.07 for ST2 and ST3 respectively. Taste of ST1 was found to be most favoured with an average rating of 7.67 followed by 5.70 for both ST2 and ST3. Appearance of ST1 was the most preferred among the ST3 with average rating of 7.97 followed by 5.67 and 4.87 for variation ST2 and ST3 respectively. ST1 was found to be the most popular and palatable option among the developed products.

The sensory acceptance of Sprouts Tikki, particularly made with sprouted moong, is generally favourable, as indicated by scores across various sensory attributes. In a study evaluating similar products, the Tikki received scores of 7.75 for appearance and texture, and 7.66 for taste and aroma. These results suggest that the Tikki is appealing to consumers, with its taste and aroma significantly enhanced by the inclusion of microgreens. The overall acceptability score of 7.75 indicates that this dish not only offers a delightful sensory experience but also provides nutritional benefits, making it a popular choice among health-conscious individuals (Kumari *et al.,* 2023).

4.3.2.1.2.Ragi Brownie

Three variations of Ragi Brownie were assessed for sensory evaluation. Table XXVII shows the results of One-Way -ANOVA for sensory evaluation score of Ragi Brownie. Figure 6 shows the Radar Graph for sensory evaluation of Ragi Brownie.

Table XXVII. Statistical Analysis of Sensory Evaluation of Ragi Brownie

Variations	Mean ± Standard Deviation	F value	p-value
RB1	7.10±0.721	5.109	0.011
RB2	6.75±1.136		
RB3	6.11±0.916		

The results in Table XXVII showed that RB1 was having a mean score of 7.10±0.721 followed by 6.75±1.136 for RB2 and 6.11±0.916 for RB3. The p-value was 0.011 which is less than 0.05. Therefore, there is a significant difference in the overall acceptability between the three variations of Ragi Brownie. RB1 was the most acceptable variation among the three variations and it further underwent nutrient and shelf-life analysis.

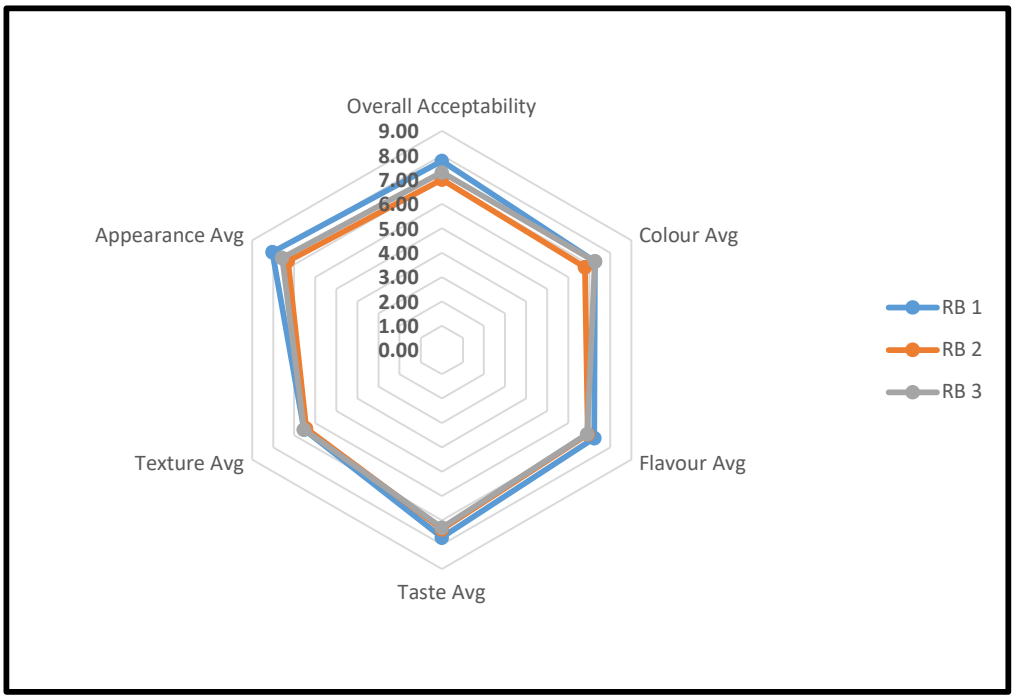

Figure 6. Radar graph for Sensory Evaluation of Ragi Brownie

The average score for colour for RB1 and RB3 were 7.26 followed by RB2 with an average score of 6.8. Flavour of RB1 was rated among the highest with an average rating of 7.23 followed by 6.93 for RB2 followed by 6.90 of RB3. Taste for RB1 was the highest rated variation with an average rating of 7.7 followed by 7.36 and 7.33 for RB2 and RB3 respectively. Texture of RB1 was found to be most favoured with an average rating of 8.03 followed by 7.3 and 7.56 for RB2 and RB3 respectively. RB1 with 100 per cent ragi flour was found to be the most popular and palatable option among the developed products of Ragi Brownie.

In a study conducted by Selvakumaran *et al.,* (2019) it was stated that attributes like sweetness, bitter chocolate, burnt chocolate, mocha, salty, and sweet flavours are commonly identified in brownies. The sensory score of brownies is crucial for producers to understand consumer preferences and improve their products. For example, a study on gluten- and lactose-free brownies identified colour and texture as key characteristics that should be improved for such formulations to enhance consumer acceptance.

4.3.2.1.3.Nutri Ball

The three variations of Nutri Ball were assessed for sensory evaluation. Table XXVIII shows the results of One-Way -ANOVA for sensory evaluation score of Nutri Ball. Figure 7 shows the Radar Graph for sensory evaluation of Nutri Ball.

Table XXVIII. Statistical Analysis of Sensory Evaluation of Nutri Ball

Variations	Mean ± Standard Deviation	F value	p-value
NB1	6.8±1.074	0.324	0.019
NB2	6.57±0.973		
NB3	7.4±1.125		

Table XXVII presents the One-Way –ANOVA for Nutri Ball. The mean value for NB1 was 6.8±1.074, NB2 was 6.57±0.973 and NB3 was 7.4±1.125. The p value was 0.019 which is less than 0.05. The mean value depicted that NB3 was the most acceptable variation of Nutri Ball Therefore there is a significant difference in overall acceptability between the three variations of Nutri Ball.

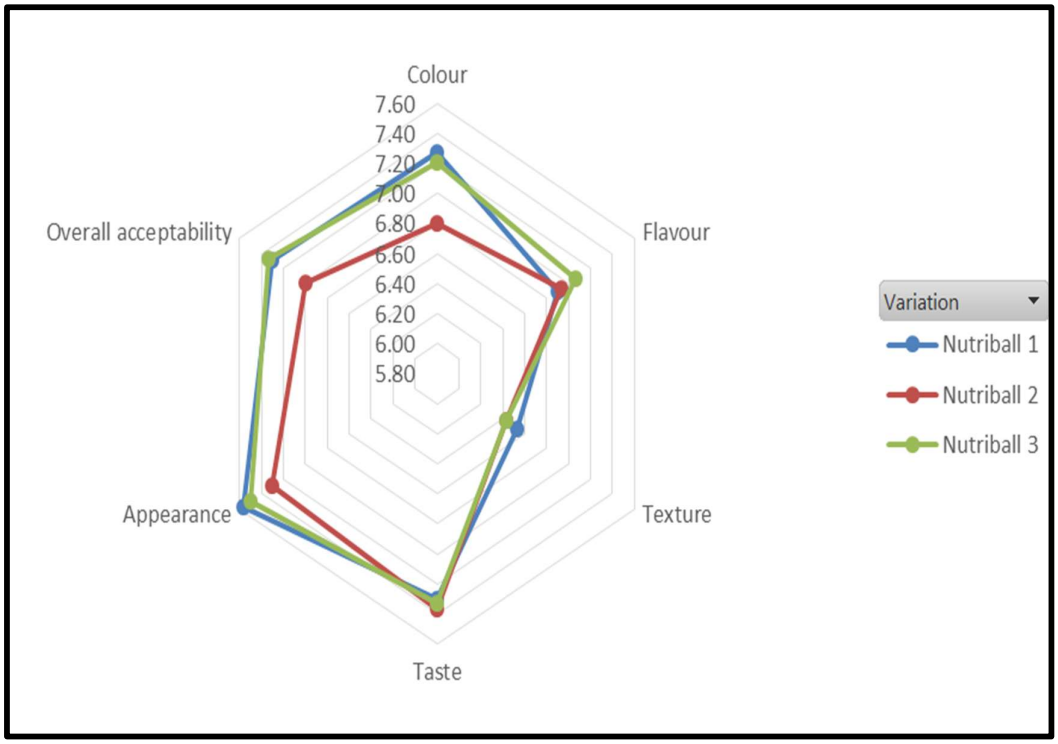

Figure 7. Radar graph for Sensory Evaluation of Nutri Ball

Average score for colour for NB1 was 7.27 followed by NB2 and NB3 with an average score of 6.8 and 7.2 respectively. Flavour of NB3 was rated among the highest with an average rating of 7.07 followed by 6.93 for NB2 followed by 6.90 of NB1. Texture for NB1 was the highest rated variation with an average rating of 6.53 followed by 6.43 for both NB2 and NB3. The taste of NB1 was found to be most favoured with an average rating of 7.37 followed by 7.33 and 7.30 for NB3 and NB2 respectively. Appearance of NB1 was the most preferred among the 3 variations with average rating of 7.57 followed by 7.50 and 7.30 for NB3 and NB2 respectively. NB3 was found to be the most acceptable among the three variations of the developed products.

The sensory evaluation of Nutri Balls, which incorporate quinoa along with a blend of oats, wheat flour, semolina, Bengal gram flour, fat, dry fruits, and sugar, was conducted by a semi-trained panel. The evaluation focused on attributes such as colour, consistency, taste, and overall acceptability, using a 9-point hedonic rating scale. The results indicated that the Nutri Balls were well-received, with favorable scores across all attributes, reflecting high consumer acceptability (Mihafu *et al.,* 2020).

4.3.2.2.Cost Effectiveness of the Dietary Supplements

Regarding dietary supplements, cost effectiveness and affordability are important factors to be considered for including them in their daily dietaries. Consumers are always looking for products that provide value for their money without compromising on quality and quantity of products. In this section, the cost calculation of dietary supplements which were favoured by the sensory panel in sensory evaluation is further assessed for cost calculation. The variations of products developed favoured, Ragi Brownie (RB1), Nutri Ball (NB3), and Sprouts Tikki (ST1), were explored and discussed in the following pages.

Ragi Brownie is known for its delicious taste and nutritional significance. By analysing the cost per serving and comparing it with similar products available in the market, affordability of the product was determined. Similarly, Nutri Ball and Sprouts Tikki offered unique health benefits but at different price points. By evaluating their cost effectiveness, selected subjects can make informed decisions about which product suits their budget and dietary needs. Understanding the cost calculation of these dietary supplements allowed the selected subjects to prioritize their health goals while not putting a hole in the pocket. It also helped to identify any potential hidden costs or additional expenses associated with these dietary supplements.

Specific pricing details of each dietary supplements are provided and a comprehensive analysis of the cost effectiveness of these dietary supplements are carried out. By doing so, the selected subjects will gain a better understanding of these products and make better lifestyle choices while ensuring the best value for the money.

4.3.2.2.1.Sprouts Tikki (ST1)

Sprouts Tikki was prepared with the ingredients that were commonly available in the local markets and used by common people. As the product, Sprouts Tikki was developed to supplement the selected subjects with folic acid deficiency and overweight, the ingredients like whole green gram and whole bengal gram are rich in folic acid. As the sprouted Bengal gram and green gram were used for Sprouts Tikki it can be used for supplementing overweight subjects as sprouts provide fibre and are economically feasible. The ingredients were not seasonal and were available easily. The result of cost calculation for making 100g of Sprouts Tikki (ST1) is furnished in Table XXIX.

Table XXIX. Cost Calculation of Sprouts Tikki (ST1)

Ingredients	Quantity(g)	Cost(Rs)
Bengal gram (whole)	50	5
Green gram (whole)	40	6
Garlic	10	2.5
Chilli powder	2	1.2
Asafoetida	1	1.7
Salt	1	0.04
Total	104	16.44

The results in Table XXIX presents that cost of 50g of bengal gram (whole) costs Rs 5, 40 grams of Green gram (whole) costs Rs 6, 10g of Garlic costs Rs 2.5, 2g of chilly powder costs Rs 1.2, 1 g of Asafoetida costs Rs 1.7 and 1g of salt costs Rs 0.04. All these were formulated to get 100 g of Sprouts Tikki. The total cost of ingredients for 100 grams of Sprouts Tikki (ST1) comes out to be Rs 16.44. Electricity and packaging used for the product were considered as overhead cost. The cost of 1 unit of current which was used for 20min of baking comes at Rs.4.5 and cost of packaging for 100g of Sprouts Tikki was Rs.1.4. Therefore, total cost of 100g (4 pieces) of Sprouts Tikki (ST1) was Rs. 22.34. The Sprouts Tikki is affordable by the common person to fulfil the nutritional requirements for folic acid and to reduce overweight in selected subjects.

4.3.2.2.2.Ragi Brownie (RB1)

The idea of developing a millet brownie was a tedious task. Ragi Brownie should match the taste and be cost effective. The barrier in nutritional supplementation was the cost of the ingredients and the cost for supplementing a large population. The decision to make Ragi Brownie was derived as it was the most liked food by the young adult population. It is important to note that the cost of food was calculated accurately by considering all the ingredients used for the formulation of Ragi Brownie. The result of cost calculation of Ragi Brownie (RB1) is presented in Table XXX.

Table XXX. Cost Calculation of Ragi Brownie (RB1)

Ingredients	Quantity (g)	Cost(Rs)
Ragi Flour	50	3.5
Jaggery	40	2.8
Sesame seeds	20	4
Curd	50 ml	3.5
Oil	5 ml	0.75
Cocoa powder	1	1.5
Baking powder	1	0.3
Total	167	16.35

Table XXX shows that cost calculation of 50 g of Ragi flour used in Ragi Brownie (RB1) was Rs 3.5 rupees, 40 g of Jaggery was Rs 2.8, 20g of sesame seeds was Rs 4, 50 g of curd cost Rs 3.5, 5 ml of oil was Rs 0.75, 1g of cocoa powder was Rs 1.5 and 1 g of baking powder was Rs 0.3. These ingredients were procured from the local market for the preparation of 100 g of Ragi Brownie. The total cost of ingredients for 100 g (4 pieces) of Ragi Brownie (RB1) was worked out at Rs 16.35. Electricity and packaging used for the product were considered as overhead cost. The cost of 1 unit of current which as used for 20min of baking was Rs.4.5 and cost of packaging for 100g of Sprouts Tikki was Rs.1.4. Therefore total cost of 100g of Ragi Brownie (RB1) comes at Rs. 22.25.

The cost of brownies in the Indian market typically ranges from Rs. 60 to Rs. 120 for servings between 80g and 250g, depending on factors such as ingredients, brand, and location. For instance, popular brands like brownie point India offer eggless brownies priced between Rs. 60 to Rs. 90 for an 80g serving. A study on millet brownies indicated a total cost of approximately Rs. 118.96 for a 250g batch, encompassing ingredient costs, processing, and profit margins. Key cost components include the price of ingredients like flour, sugar, and chocolate, along with overheads such as utilities and labour (Widyasari *et al.,* 2022).

4.3.2.2.3.Nutri Ball (NB3)

Nutri balls refer to various types of nutritious snacks that typically consist of blended seeds, fruits, and other ingredients such as nut butters and protein powders. These products aim to provide a convenient, healthy option for consumers seeking satisfying and nourishing snacks. These homemade snacks are quick to prepare and provide a combination of protein, carbohydrates, fiber, and healthy fats, making them a great snack throughout the day (Matthew Kadey, 2016). The result of cost calculation of Nutri Ball (NB3) is presented in Table XXXI.

Table XXXI. Cost Calculation of Nutri Ball (NB3)

Ingredients	Quantity (g)	Cost(Rs)
Bengal Gram	30	3.75
Ground nuts	10	1.5
Bajra	20	1.6
Horse gram	20	2.5
Gingelly seeds	10	3.5
Dates	10	3.1
Jaggery	20	1.5
Total	120	17.45

The results for cost calculation of Nutri Ball (NB3) depicts those 30 grams of bengal gram was Rs 3.75, 10g of Ground nut was Rs 1.5, 20g of bajra costed Rs 1.6, 20 g of Horse gram was purchased for Rs 2.5, 10 g of Gingelly seeds costed Rs 3.5, 10 g of Dates costed Rs 3.1 and 10g of Jaggery was Rs 0.75. The selected subjects were provided with 100 g of the developed product. The total cost of ingredients for 100 grams of Nutri Ball (NB3) was worked out as Rs 17.45. Electricity and packaging used for the product were considered as overhead cost. The cost of 1 unit of current which as used for 20 min of mixer came at Rs.4.5 and cost of packaging for 100g of Sprouts Tikki was Rs.1.4. Therefore total cost of 100g of Nutri Ball (NB3) comes at Rs.23.35.

4.3.2.2.4.Cost Comparison of Dietary Supplements with Commercially available similar Products

The cost of the developed dietary supplements was compared with the commercially available similar products. The results of the comparisons are shown in Table XXXII.

Table XXXII. Cost Comparison of dietary supplements and commercially available similar products

Dietary Supplements	Cost for 100 g (Rs)	Commercially similar product (100g) (Rs)
Sprouts Tikki (ST1)	22.34	65
Ragi Brownie (RB1)	22.25	70
Nutri Ball (NB3)	23.35	50

The results showed that 100g of Sprous Tikki (ST1) costed Rs 22.34 whereas the commercially available similar product of Aloo Tikki costed Rs 65 (Kavyasri and Vaijayanthi, 2022). There is a notable difference of Rs 42.66 within the commercially available similar product and Sprouts Tikki. The cost of 100g of Ragi Brownie (RB1) was Rs 22.25. The commercially available 100g of Brownie costed Rs 70 (Masih *et al.,* 2019). A notable difference of Rs 47.75 between the commercially available and formulated Ragi Brownie was noted. The developed Nutri Ball was compared with commercially available Bajra balls as bajra being the major ingredient in Nutri Ball. The cost of 100g of Nutri Ball (NB3) was Rs 23.35 and commercially available 100 g of bajra ball was Rs 50 rupees (Gupta, 2020). Difference of Rs 26.65 was noted between the commercially available and formulated supplement of Nutri Ball. It was interesting to note that the formulated dietary supplements were nutritionally adequate to fulfil the requirements of Triple Burden of malnutrition at affordable cost.

4.3.2.3.Nutrient Analysis of the Dietary Supplements

Nutrient analysis plays a crucial role in understanding the nutritional composition of various food products. By examining key components such as moisture, ash, energy, carbohydrates, protein, fat, iron, calcium, dietary fiber, crude fibre and folic acid, we can gain valuable insights into the health benefits and potential effect of these products on health and well-being.

The Recommended Dietary Allowance of young adult women of age 18-21 years is shown in Table XXXIII.

Table XXXIII. ICMR RDA for Sedentary working Woman

Nutrients	ICMR RDA (2020)	1/3rd of RDA
Energy (Kcal)	1645	548.3
Carbohydrates (g)	130	43.3
Protein (g)	45.7	15.2
Fat (g)	20	6.6
Iron (mg)	29	9.6
Calcium (mg)	1000	333.3
Dietary Fibre (g)	25	8.3
Folic acid (µg)	220	73.3

Table XXXIII shows the ICMR RDA (2020) and one-third of RDA required to meet through nutritional supplementation. The one-third RDA required by young adult women of the age-18-21 years is 548.3 Kcal, 43.3g, 15.2g, 6.6g, 9.6mg, 333.3mg, 8.3g, 73.3 µg of energy, carbohydrates, protein, fats, iron, calcium, fibre and folic acid respectively. The aim of the nutritional supplementation was to meet one-third of the nutritional requirement through the developed products. The Nutrient Analysis of 100g of Sprouts Tikki**,** Ragi Brownie and Nutri Ball were carried, and the results are presented in Table XXXIV.

Table XXXIV. Nutrient content of Sprouts Tikki, Ragi Brownie and Nutri Ball

Nutrients	Dietary Supplements		
	Sprouts Tikki (ST1)	Ragi Brownie (RB1)	Nutri Ball (NB3)
Moisture(g)	15.33	12.16	12.1
Ash(g)	7.13	7.22	7.26
Energy (Kcal)	485	406	465
Carbohydrates (g)	31.1	64.2	62.1
Protein (g)	17.6	10.6	15.5
Fat (g)	5.3	3.8	17.2
Iron (mg)	3.4	5.1	10.3
Calcium (mg)	186	256.9	186
Folic acid (µg)	81.2	38.1	33.1
Dietary Fibre(g)	12	6	8.4
Crude Fibre(g)	7.5	4.6	6.2

4.3.2.3.1.Sprouts Tikki (ST1)

The results in the Table XXXIV of Nutrient Analysis of Sprouts Tikki (ST1) showed that moisture content of the product was 15.33g, Ash content was 7.13g, Energy in the product was 485 Kcal, Carbohydrates was 31.1g, Protein was 17.6 g, Fat content was 5.3 g, Iron present in the product was 3.4mg, Calcium content was 186 mg, Folic acid content was 81.2, Dietary Fibre content was 12 g and Crude Fibre was at 7.5g. The calculated nutrient value for Vitamin C was 2.524 mg. As Sprouts Tikki had been prepared from sprouted Bengal gram and green gram, the product has good amount of fibre. The required one-third RDA dietary fibre was 8.3g and Sprouts Tikki (ST1) contained 7.5 g of Crude Fibre and 12 g of Dietary Fibre as suggested for the selected subject in the category of over-weight and folic acid deficiency in the Experimental group.

Similar study conducted by Sharma *et al.,* (2020), where the researchers developed a Sprouted Bengal gram pickle, for 100 g of the product, Carbohydrate was 31.66g, energy was 383Kcal, Protein at 11.26g, Dietary Fibre was 13.6g and Fat was at 23.48g. Similar results were seen in Sprouts Tikki where the major ingredient was sprouted bengal gram.

4.3.2.3.2.Ragi Brownie (RB1)

The results for Nutrient content in Ragi Brownie (RB1) depicted that the moisture content was 12.16g and ash content was 7.22g. The micro and macro nutrients present in Ragi Brownie (RB1) was 406 Kcal of Energy, 64.2 g of Carbohydrate, 10.6 g of Protein, 3.8g of Fat, 5.1mg of Iron, 256.9 mg of Calcium, 38.1 µg of Folic acid, 6 g of Dietary Fibre and 4.6g of Crude Fibre and was suggested for the selected subjects in the category of calcium deficiency in Experimental Group.

In a similar study by 100g of ragi cake had a calcium content of 168.45 (Anitha *et al.,* 2021). A high content in Ragi Brownie (RB1) can be accounted for the usage of curd, sesame seeds and dates in the development of Ragi Brownie. Sesame or Gingelly seeds are a good source of calcium.

4.3.2.3.3.Nutri Ball (NB3)

The results depicted that the moisture content in Nutri Ball (NB3) was 12.1g and ash content of Nutri Ball was 7.26g. The calculated value of Vitamin C was 0.44mg. The micro and macro- nutrient content of Nutri Ball through Nutrient Analysis was energy content was 465 Kcal, carbohydrate content was 62.1g, protein content was 15.5g, fat

content was 17.2g, iron was 10.3mg, calcium content was 186 mg, folic acid content was 33.1 µg, dietary fibre content was 8.4g and crude fibre was 6.2g.

Nutri balls made from bajra (pearl millet) are a nutritious snack option, rich in essential nutrients. A typical serving of bajra provides approximately 360-380 calories per 100 grams, with a macronutrient composition that includes around 6 grams of protein, 2 grams of dietary fiber, and significant amounts of carbohydrates. Additionally, bajra is a good source of essential minerals such as magnesium, iron, phosphorus, and zinc, contributing to overall health and wellness. Furthermore, bajra is gluten-free, making it suitable for individuals with gluten intolerance or celiac disease, and its antioxidant properties may help combat inflammation and support heart health (Shukla & Bhise, 2023).

4.3.2.4.Anti- Nutrient Analysis of the Dietary Supplements

Table XXXV depicts the Phytic acid content in Sprouts Tikki, Ragi Brownie and Nutri Ball.

Table XXXV. Anti-Nutrient Analysis (Phytic Acid) of dietary supplements

Dietary Supplements	Phytic Acid* (mg/100g)
Sprouts Tikki (ST1)	0.450
Ragi Brownie (RB1)	0.131
Nutri Ball (NB3)	0.110

*Pramitha *et al.,* 2020

4.3.2.4.1.Sprouts Tikki (ST1)

Phytic acid content in Bengal gram was assessed as Bengal gram consist of phytic acid which will hinder the absorption of nutrients. The phytic acid content in Sprouts Tikki (ST1) was 0.450mg/100g.

Research indicates that the phytic acid content varies among different legumes, with soybean having the highest content followed by urad bean, pigeon pea, mung bean, and chickpea having relatively lower levels (Rosa-Sibakov *et al.,* 2018).

To mitigate the effects of phytates in chickpeas and other legumes, soaking before cooking and pairing them with vitamin C-rich foods can help increase the availability of minerals like iron and zinc. These practices can reduce or eliminate the impact of antinutrients on

mineral absorption (Gu *et al.,* 2023). These processing techniques of soaking, sprouting was used in the development of Sprouts Tikki to reduce the phytic acid content in the product.

4.3.2.4.2.Ragi Brownie (RB1)

The phytic acid was analysed for Ragi Brownie. The major ingredient in the product is Ragi flour. Most of the millets consist of phytic acid as the major anti-nutrient. The pytic acid content in Ragi Brownie (RB1) was 0.131 mg/100g.

The phytic acid content in raw ragi (finger millet) is relatively high, ranging from 4.77 to 8.6 mg/g. Specifically, the phytic acid content in raw ragi was reported as 5.69 ± 0.19 mg/g. Roasting and germination of ragi reduced the phytic acid content by 61.5 and 49.2 per cent respectively. Fermentation of ragi overnight and then adding curd reduced the phytic acid content by up to 49.18. Cooking ragi reduced the phytic acid content by 11.71-16.14 (Sheethal *et al.,* 2022) and (Kumar *et al.,* 2021). Roasting was used in the development of Ragi Brownie which can be a factor for the reduction of phytic acid content in the product.

4.3.2.4.3.Nutri Ball (NB3)

Nutri Ball is a mixture of ingredients which include bajra, horse gram etc. The conventional method of roasting, soaking and fermentation can restrict the presence of phytic acid in food to a greater extent. The phytic acid content in Nutri Ball (NB3) was 0.110 mg/100g.

The phytic acid content in raw pearl millet (bajra) is in the range of 4.77 ± 0.07 mg/g to 8.6 ± 0.15 mg/g (Sheethal *et al.,* 2022) and (Krishnan and Meera, 2018).

The phytic acid content in horse gram is significant, with phytic acid being considered an anti-nutrient due to its ability to inhibit the digestibility of proteins and reduce the bioavailability of minerals like calcium, zinc, iron, and magnesium. However, soaking, sprouting, or cooking horse gram seeds before consumption can significantly reduce the phytic acid content, making the nutrients more available for absorption (Prasad and Singh, 2015). Roasting of all the ingredients was carried out in the development of Nutri Ball to reduce the phytic acid content in the developed product.

4.3.2.5.Microbial Analysis of Dietary Supplements

Shelf life analysis is a crucial aspect of product development and quality control in various industries. By examining factors such as pH, Total Fungal Count (TFC), and Total

Plate Count (TPC), the researcher can determine the stability and safety of their products over time.

The pH level plays a significant role in determining the shelf life of a product. It affects microbial growth and enzymatic reactions that lead to spoilage. By monitoring the pH throughout the shelf life, the researcher identifies potential issues and make necessary adjustments to extend the product's longevity. Total Fungal Count and Total Plate Count are key indicators of product safety. These counts measure the presence of microorganisms that cause spoilage or pose health risks to consumers. Regular testing at different stages of the shelf life allows researcher to identify any increase in microbial activity and take appropriate measures to prevent contamination or deterioration. Analysing these factors not only helps ensure product quality but also enables researcher to meet regulatory requirements and maintain trust of the selected subjects. With accurate data on pH, Total Fungal Count, and Total Plate Count, companies can confidently determine the appropriate expiration dates for the products and provide consumers with reliable information about their safety and with this background information all the following data were collected and discussions presented in the following pages.

4.3.2.5.1.Sprouts Tikki (ST1)

Sprouts Tikki (ST1) was examined for a shelf-life period of 4th and 7th day as the moisture content was 15.33g/100g and the results of Shelf-life analysis are depicted in Table XXXVI. Plate 13 showed TPC Analysis and Plate 14 depicted TFC Analysis of Sprouts Tikki (ST1).

Table XXXVI. Shelf-life analysis of Sprouts Tikki (ST1)

Attributes for Shelf life study	4th Day	7th Day	Maximum acceptable range
pH	6.5	7.0	6.5-8
Total Fungal Count	Less than 10cfu/g	1x10^2 cfu*/g	≤10cfu/g
Total Plate Count	200cfu/g	15x10^2 cfu/g	Max 1000cfu/g

*cfu/g - colony-forming unit per gram

Table XXXVI presents the results of Shelf-life analysis for Sprouts Tikki (ST1) where the pH for the 4th day was 6.5 and for 7th day was 7. The acceptable range for pH was 6.5-8. The Total Fungal Count for the 4th day was less than 10cfu/g and for 7th day was 1x10^2 cfu*/g. The desirable range for Total Fungal Count is ≤10cfu/g. The Total Plate Count

for the 4th day was 200cfu/g and 7th day was $15x10^2$ cfu/g. The maximum desirable limit was 1000cfu/g. Therefore, the expiry date of Sprouts Tikki (ST1) was 7 days from the day of formulation of the products.

Plate 13. TPC Analysis of Sprouts Tikki for 4th and 7th day

Plate 14. TFC Analysis of Sprouts Tikki for 4th and 7th day

The study conducted by D'ambrosio *et al.,* (2017), where products from quinoa sprouts were subjected to Shelf-life Analysis. The results show that the Quinoa Sprouts were still marketable till 7 days of the development of the product. The same observation was seen in Sprouts Tikki also.

4.3.2.5.2.Ragi Brownie (RB1)

The shelf life of Ragi Brownie (RB1) was examined for 7th and 10th day of the product after the product development. The days for shelf-life analysis were decided depending up on the moisture content of the product. The shelf-life analysis of Ragi Brownie (RB1) are presented in Table XXXVII. Plate 15 depicts TPC Analysis and Plate 16 shows TFC Analysis of Ragi Brownie (RB1).

Table XXXVII. Shelf-life analysis of Ragi Brownie (RB1)

Attributes for Shelf life study	7th day	10th day	Maximum acceptable range
pH	6.5	6.8	6.5-8
Total Fungal Count	Less than 10cfu/g	$1x10^2$ cfu*/g	≤10cfu/g
Total Plate Count	230cfu/g	$48X10^2$cfu/g	Max 1000cfu/g

*cfu/g - colony-forming unit per gram

The results in Table XXXVII depicted that shelf life of Ragi Brownie (RB1) which had a pH of 6.5 on 7th day and 6.8 on 10th day. The desirable range of pH is 6.5-8. The Total Fungal Count for 7th day was less than10 cfu/g and for 10th day it was $1x10^2$ cfu/g. The desirable range of Total Fungal Count was ≤10cfu/g. The Total Plate Count was 230cfu/g for 7th day and $48X10^2$cfu/g for 10th day. The maximum desirable limit was 1000cfu/g. According to the shelf-life analysis, Ragi Brownie (RB1) will be fit for consumption till 10th day.

Plate 15. TPC Analysis of Ragi Brownie (RB1) for 7th and 10th day

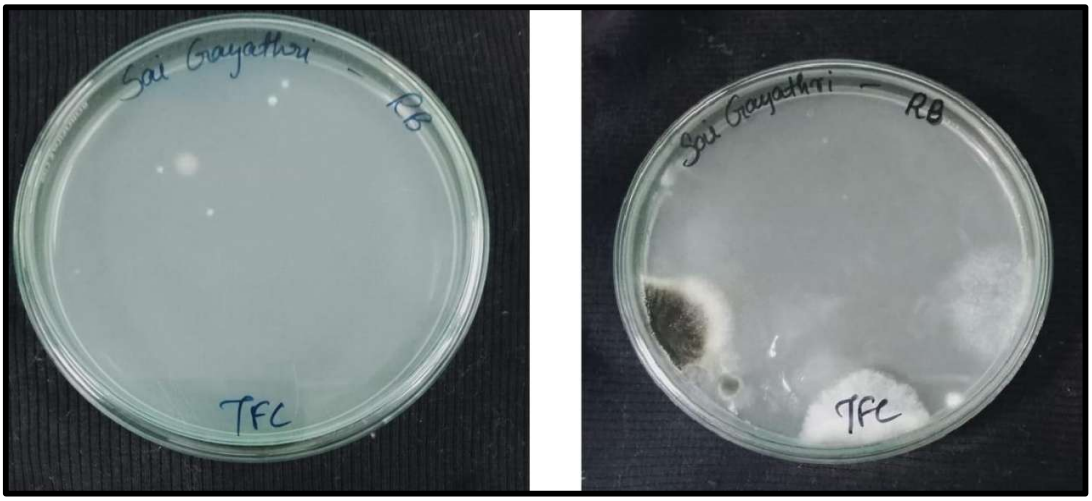

Plate 16. TFC Analysis of Ragi Brownie (RB1) for 7th and 10th day

In a study conducted by Luna (2022) on steamed millet brownies, mild rancidity appeared after 7 days of storage at room temperature. Total number of microorganisms (mold, yeast, bacteria) in brownies increased from 8 x $10^1$to 2.1 x 10^6 CFU/g after two weeks storage. Ragi Brownie had a shelf life of 10 days at room temperature.

4.3.2.5.3.Nutri Ball (NB3)

The Shelf-life analysis of Nutri Ball (NB3) was carried out for 7th and 10th day. The Table XXXVIII depicts the result for Shelf-life analysis. Plate 17 shows TPC Analysis and Plate 18 depicts TFC Analysis of Nutri Ball (NB3).

Table XXXVIII. Shelf-life analysis of Nutri ball (NB3)

Attributes for Shelf life study	7th Day	10th Day	Maximum
pH	6.6	7.0	6.5-8
Total Fungal Count	Less than 10cfu/g	$2x10^2$ cfu*/g	≤10cfu/g
Total Plate Count	100cfu/g	$50x10^2$ cfu/g	Max 1000cfu/g

*cfu/g - colony-forming unit per gram

The result in Table XXXVIII represents that pH of Nutri Ball (NB3) for 7th day was 6.6 and for 10th day was 7. The desirable Total Fungal Count for 7th day was less than 10cfu/g and 10th day was $2x10^2$ cfu/g. The desirable range for Total Fungal Count is

≤10cfu/g. The Total Plate Count for the 7th day was 100cfu/g and for 10th day was 50x10^{2} cfu*/g. The maximum limit of Total Plate Count is 1000cfu/g. Therefore, according to the shelf-life analysis the shelf-life of Nutri Ball (NB3) will be for 10 days.

A study was conducted by Mahalakshmi Sangeetha *et al.,* (2020) on Nutri Ball developed from rice flakes and bajra**.** It was concluded that Nutri Ball had a shelf life of six days at room temperature. The shelf life was extended if stored under refrigerated conditions. The shelf-life of Nutri Ball was 10 days at room temperature.

Plate 17. TPC Analysis of Nutri Ball (NB3) for 7th and 10th day

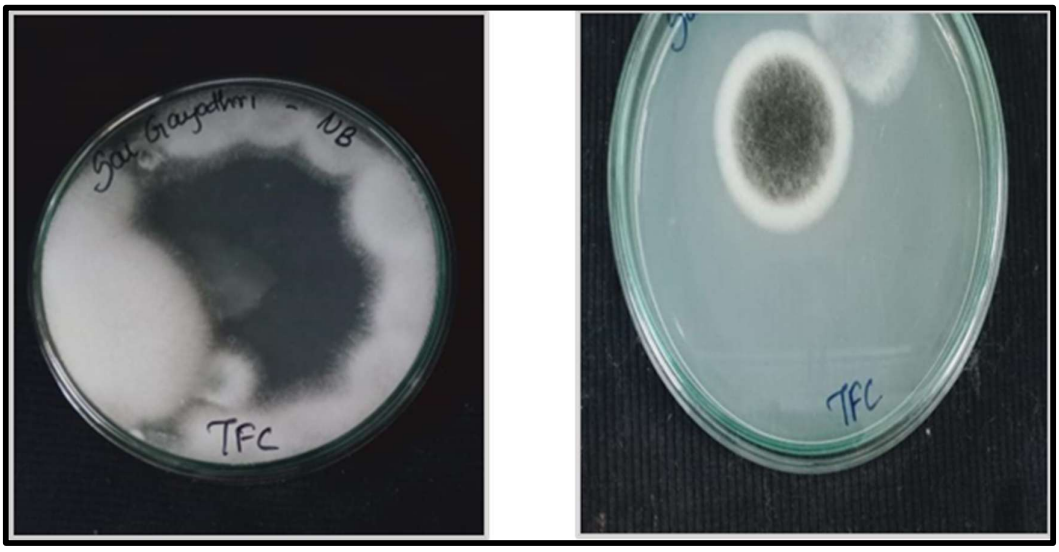

Plate 18. TFC Analysis of Nutri Ball (NB3) for 7th and 10th day

Phase-IV

4.4.Effect of Nutrition Education on the Nutritional Knowledge of Triple Burden of Malnutrition among the selected subjects

4.4.1.Knowledge, Attitude and Practice (KAP) Study

In nutrition education, the KAP model (Knowledge, Attitude and Practice) plays a crucial role in shaping individuals' behaviours and choices regarding their dietary habits. Knowledge is the foundation upon which individuals build their understanding of nutrition principles and guidelines. Attitude influences how they perceive and value this knowledge, ultimately impacting their willingness to adopt healthy eating habits. The practice then translates this knowledge and a positive attitude into actionable steps and behaviours that promote better nutrition practices. By applying the KAP model in nutrition education initiatives, researcher empowers the individuals to make informed decisions about their diet, cultivate a positive attitude towards healthy eating, and ultimately adopt sustainable practices that support their overall health and well-being.

KAP (Knowledge, Attitude and Practice) study is a valuable tool in the field of nutrition education, particularly when targeting young adult women. This study aims to assess the impact on subject’s knowledge, attitudes and practice towards nutrition and healthy eating habits. By conducting a KAP study, researchers gathered important insights into the level of understanding of young adult women have on nutrition related aspects. This included their knowledge about nutrients, portion sizes, food groups, and the impact of diet on overall health with special reference to optimum nutrition, under nutrition and over nutrition.

4.4.1.1.Effect of Nutrition Education on Nutrition Knowledge of the selected subjects in Experimental Group

Table XXXIX shows the results of effect of nutrition education module on Knowledge of the selected subjects in Experimental Group for pre and post nutrition intervention for the period of three months.

Table XXXIX. Effect of Nutrition education on Knowledge of the selected subjects in Experimental Group

Questions	Pre Intervention		Post Intervention	
	Frequency (n=250)	Per cent (%)	Frequency (n=250)	Per cent (%)
Meaning of Macro and Micro Nutrients	50	20	93	37
Meaning of Malnutrition	36	14	59	24
Meaning of balanced diet	26	10	81	32
Meaning of Dual/Double Burden of Malnutrition	12	5	86	34
Meaning of Triple Burden of Malnutrition	16	6	114	46
Balanced diet promotes health status	80	32	104	42
Meaning of Life-style related diseases	49	20	91	37
Types of deficiency diseases	40	16	72	29
Meaning of Spina Bifida	15	6	54	22
Meaning of Osteopenia	33	13	72	29

The result on knowledge of the selected subjects in Experimental Group pre and post intervention showed an overall improvement in nutritional knowledge. 37 per cent of the selected subjects showed improvement from 20 per cent on their knowledge on the meaning of macro and micronutrients. 24 per cent of selected subjects improved their knowledge on malnutrition which was 14 per cent before intervention. 32 per cent of selected subjects improved from 10 per cent on the meaning and purpose of balanced diet. 34 per cent of the selected subjects improved on the understanding of meaning of double burden of malnutrition from five per cent. There was great improvement on understanding the term triple burden of malnutrition. It had improved from six per cent to 46 per cent of selected subjects in the experimental group. The selected subjects were made aware of the different type of malnutrition and its signs and symptoms during the nutrition education period. The selected subject's perspective on balanced diet promotes overall health status from 32 per cent to 42 per cent. The nutrition education had an immense impact on their

aspects of diet and health. A proper diet and exercise can bring about a great change in the nutritional and health aspect of an individual. The selected subjects gained knowledge about lifestyle related diseases has increased from 20 per cent to 37 per cent. There was a great improvement on the knowledge about different types of deficiency diseases like anaemia. The selected subjects were only aware of Iron deficiency anaemia. It was of utmost importance to make the selected subjects aware about different types of anaemia like pernicious anaemia and megaloblastic anaemia caused by Folic acid deficiency and Vitamin B12 deficiency, in order to prevent them from consuming Iron tablets for a drop of Haemoglobin in their blood as anaemia can be also caused by other Folic acid deficiency and Vitamin B12 deficiency. Their knowledge improved from 16 per cent to 29 per cent. The selected subjects' knowledge of Spina Bifida has increased from six per cent to 22 per cent. The importance of folic acid in the diet is of prime importance during the gestational period to prevent Spina Bifida in newborn. Osteopinia is a loss of bone mineral density in adolescents to young adults. The knowledge on Osteopenia was another important aspect and that has improved from 13 per cent to 29 per cent.

In Experimental research, designs for nutrition education interventions, the control or comparison groups often do not receive any specific treatment or receive minimal intervention compared to the Experimental group. For example, control groups might not undergo educational sessions or receive standard educational materials without the additional enhancements provided to the Experimental group. Overall, well-designed research trials in nutrition education are essential for evaluating the efficacy of interventions in improving individuals' nutritional knowledge, attitudes, and practices. These studies highlighted the importance of tailored educational programs to enhance nutritional understanding and promote healthy eating habits among different populations (Amoore *et al.,* 2023).

The mean and standard deviation of pre and post nutrition education on Knowledge of selected subjects in Experimental group was carried out in SPSS. By conclusion the mean and standard deviation of pre and post nutrition education on Knowledge of selected subjects in Experimental group was 1.58± 1.09 and 3.32±1.41 respectively. There was significant change in the mean pre and post intervention values. Figure 8 depicts the Level of Knowledge of the selected subjects in Experimental group.

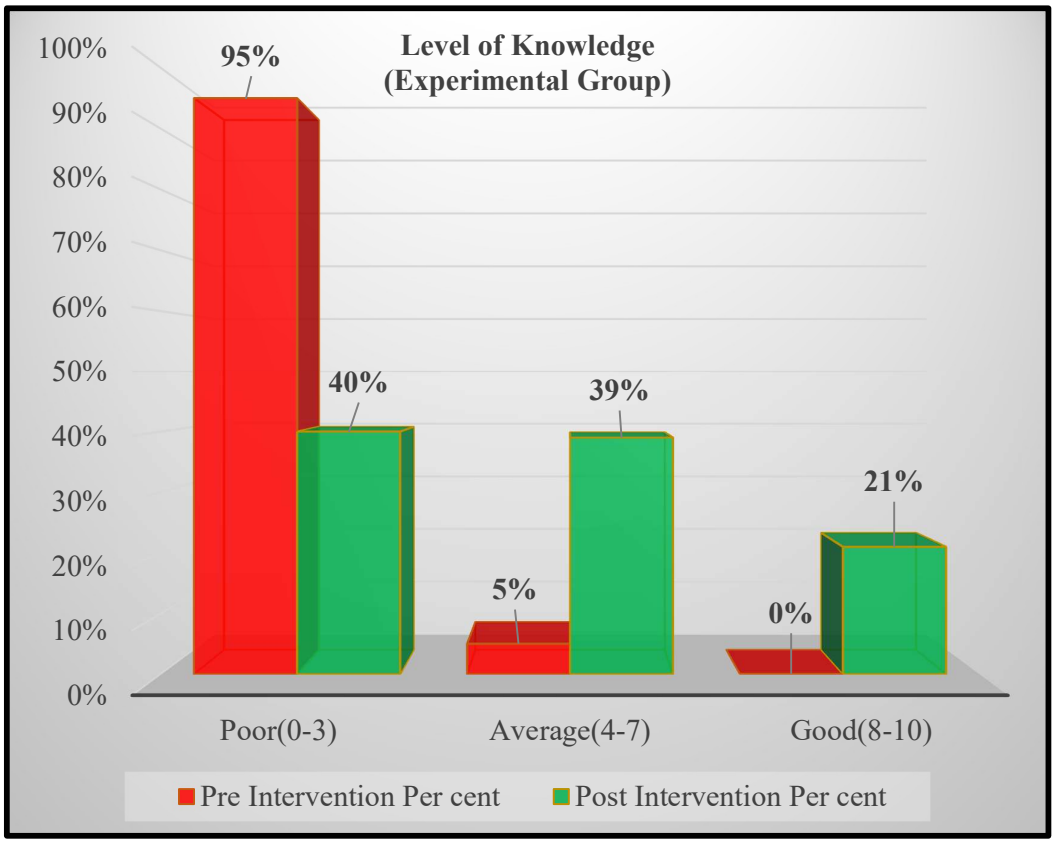

Figure 8. Level of Knowledge of the selected subjects in Experimental Group

It was observed that the level of knowledge improved among selected subjects post imparting nutritional education to the selected subjects. The per cent of poorly nutritionally informed selected subjects came down from 95 per cent to 40 per cent post intervention. A huge decrease in the subjects being poorly educated was seen in experimental group. A jump was seen in nutritionally well-informed selected subjects from five per cent to 39 per cent in average level. The subjects who belongs to good level shifted from zero per cent to 21 per cent after nutrition intervention.

4.4.1.2.Effect of Nutrition Education on Nutrition Knowledge of the selected subjects in Control Group

The Table XL shows the results of effect of nutrition education module on Knowledge of the selected subjects in Control Group pre and post nutrition intervention for the period of three months.

Table XL. Effect of Nutrition education on Knowledge of the selected subjects in Control Group

Questions	Pre Intervention		Post Intervention	
	Frequency (n=250)	Per cent (%)	Frequency (n=250)	Per cent (%)
Meaning of Macro and Micro Nutrients	60	24	64	26
Meaning of Malnutrition	49	20	53	21
Meaning of balanced diet	46	18	56	22
Meaning of Dual/Double Burden of Malnutrition	14	6	21	8
Meaning of Triple Burden of Malnutrition	16	6	27	11
Balanced diet promotes health status	62	25	76	30
Meaning of Life style related diseases	71	28	76	30
Types of deficiency diseases	31	12	43	17
Meaning of Spina Bifida	15	6	20	8
Meaning of Osteopenia	31	12	39	16

Table XL shows that there was a good response of selected subjects in the control group during the pre-intervention period. The nutritional awareness class provided to the selected subjects had made a great impact on the nutritional knowledge of the selected subjects. As the selected subjects were not provided with any nutrition education during Nutrition education period of three months, a rise in number of subjects with improved knowledge on nutritional and health aspect was not experienced. The improvement was meagre from pre-Nutrition education period to post Nutrition education period. The knowledge of selected subjects in control group about nutrients had improved from 24 per cent to 26 per cent. The awareness of the selected subjects on different types on malnutrition has improved from 20 per cent to 21 per cent. The selected subject's knowledge on balanced diet has improved from 18 per cent to 22 per cent. The awareness on different type of malnutrition (i.e.) dual burden of malnutrition has improved from six per cent to eight per

cent. The knowledge on the selected subjects on Triple Burden of Malnutrition has gone from six per cent to 11 per cent. The perspective of the selected subjects on agreeing with a diet can bring changes in health status increased from 25 per cent to 30 per cent. The knowledge on life style diseases among the selected subjects had improved from 28 per cent to 30 per cent. The knowledge of selected subjects about different types of anaemia has moved to 17 per cent from 12 per cent. The selected subject's knowledge on Spina Bifida had gone to eight per cent from six per cent. The awareness of selected subjects about Osteopenia has increased from 12 per cent to 16 per cent.

In nutrition education research, the control group does not necessarily receive no treatment. It is essential to provide sufficient detail about the control group treatment to allow for accurate interpretation of study results (Byrd-Bredbenner *et al.,* 2017).

The mean and standard deviation of pre and post nutrition education on Knowledge of selected subjects in Control group was carried out in SPSS. By conclusion the mean and standard deviation of pre and post nutrition education on Knowledge of selected subjects in Control group was 1.43± 1.07 and 2.01±1.11 respectively. There was significant change in the mean pre and post intervention values. Figure 9 depicts the Level of Knowledge of the selected subjects in Control group.

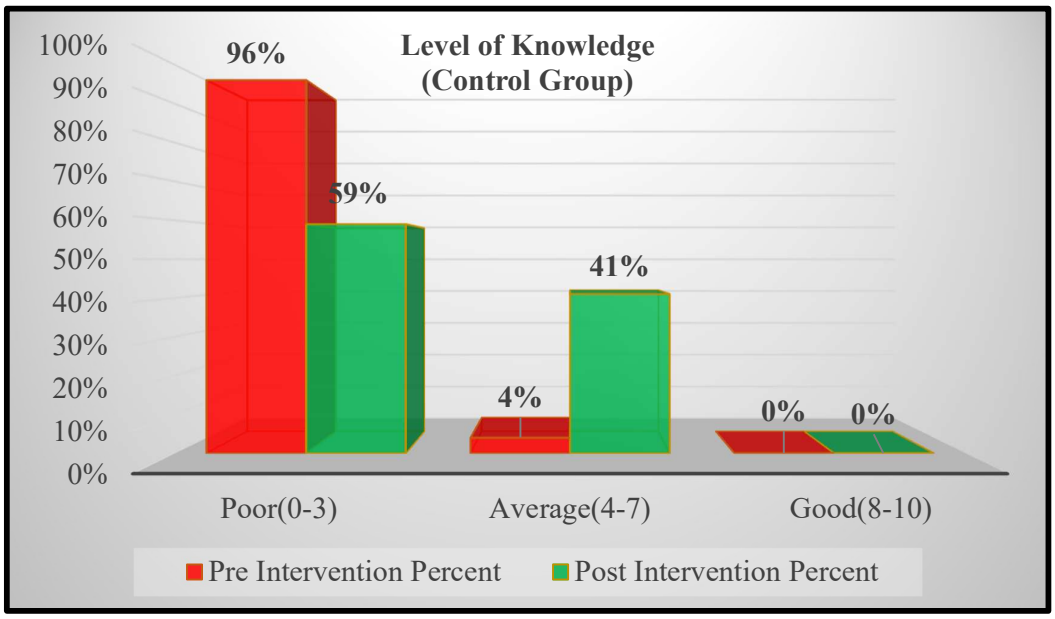

Figure 9. Level of Knowledge of the selected subjects in Control Group

It was observed that the level of knowledge improved among selected subjects in post intervention. The per cent of poorly nutritionally informed among the selected subjects

came down from 96 per cent to 59 per cent post impartment of nutritional education. A jump was seen in nutritionally informed selected subjects from 4 per cent to 41 per cent in the average level of knowledge group. There was negligible shift in per cent in good level.

4.4.1.3.Effect of Nutrition Education on Attitude towards Nutritional concepts among the selected subjects in Experimental Group

Examining attitudes towards nutrition can provide valuable information about how these individuals perceive healthy eating. It helps to identify any misconceptions or barriers that may exist in adopting healthier food choices. Understanding their attitudes allows for the development of tailored interventions that address specific concerns and motivations. The questions related to attitude was an attempt to understand if knowledge gained during the nutrition education programme will be adopted. The attitude of the person will decide how long the change or the behaviour will stay with the person. There should be a positive attitude within the person to bring about a change in the person. The Table XLI shows the results of effect of nutrition education module on Attitude of the selected subjects in Experimental Group for pre and post nutrition intervention for the period of three months.

Table XLI. Effect of Nutrition education on Attitude of the selected subjects in Experimental Group

Questions	Pre Intervention		Post Intervention	
	Frequency (n=250)	Per cent (%)	Frequency (n=250)	Per cent (%)
Skipping any meal of the day	97	39	68	27
Preference for drinking boiled water	28	11	43	17
Consumption of breakfast everyday	159	64	180	72
Preference for drinking protein shakes	73	29	53	21
Stress Eating	72	29	48	19
Consumption of raw vegetables and fruits	93	37	126	50
Consumption of Sprouts	85	34	116	46
Consumption of Instant foods (Instant Upma, Biryani etc)	71	28	51	20
Change in lifestyle can bring down occurrence of diseases	69	28	110	44
Malnutrition is always associated only with under nutrition	95	38	61	24

The results in Table XLI on Attitude of the selected subjects in Experimental Group depicts that there was an appreciable amount of improvement in Experimental Group. The selected subjects responded to the number of meals of the selected subjects skipped in a day had decreased from 39 per cent to 27 per cent. The preference of the selected subjects towards drinking boiling water increased from 11 per cent to 17 per cent. Breakfast is the main part of the day's meal. A quality breakfast gives energy to keep going for the whole day. The consumption of breakfast was improved from 64 per cent to 72 per cent. The trend of young adults to be physically fit has become a norm among the selected subjects. The proteins which the selected subjects can acquire easily through diets was being neglected and moved on in consuming protein shakes which will have an adverse effect on the body in the long run. The preference for consuming protein shakes has declined from 29 per cent to 21 per cent. Stress eating was reduced from 29 per cent to 19 per cent. The preference of having raw vegetables and fruits either in the form of salad or mixed with sprouts is preferred by 50 per cent which was 37 per cent before intervention. The preference to consume sprouts has increased from 34 per cent to 46 per cent. There was a decline in consumption of instant food over cooked food. The decline was from 28 per cent to 20 per cent. The selected subjects' awareness on lifestyle related diseases has increased from 28 per cent to 44 per cent. The nutrition education gave a clear picture on meaning and types of malnutrition. The factor of being thin was always associated with malnutrition. But nutrition education made the selected subjects understand that any improper nutrition (i.e.) more or deficit will be termed as malnutrition. There was a decline in the attitude of being undernourished is the only type of malnutrition. The decline was from 38 per cent to 24 per cent.

In Experimental Group nutrition studies, the nutritional attitude toward the Experimental Group refers to the changes in beliefs, perspectives, and motivations related to diet and nutrition that occur due to the intervention being studied. Research indicated that well-designed Experimental Groups comparing Experimental and Control groups revealed whether such changes in nutritional attitudes and behaviours are attributable to the intervention itself rather than extraneous factors (Mora and Lopez-Valcarcel, 2018).

The mean and standard deviation of pre and post nutrition education on Attitude of selected subjects in Experimental group was carried out in SPSS. By conclusion the mean and standard deviation of pre and post nutrition education on Attitude of selected subjects in Experimental group was 2.22± 1.49 and 3.56±1.47 respectively. There was significant

change in the mean pre and post intervention values. Figure 10 depicts the Level of Attitude among the selected subjects in Experimental group.

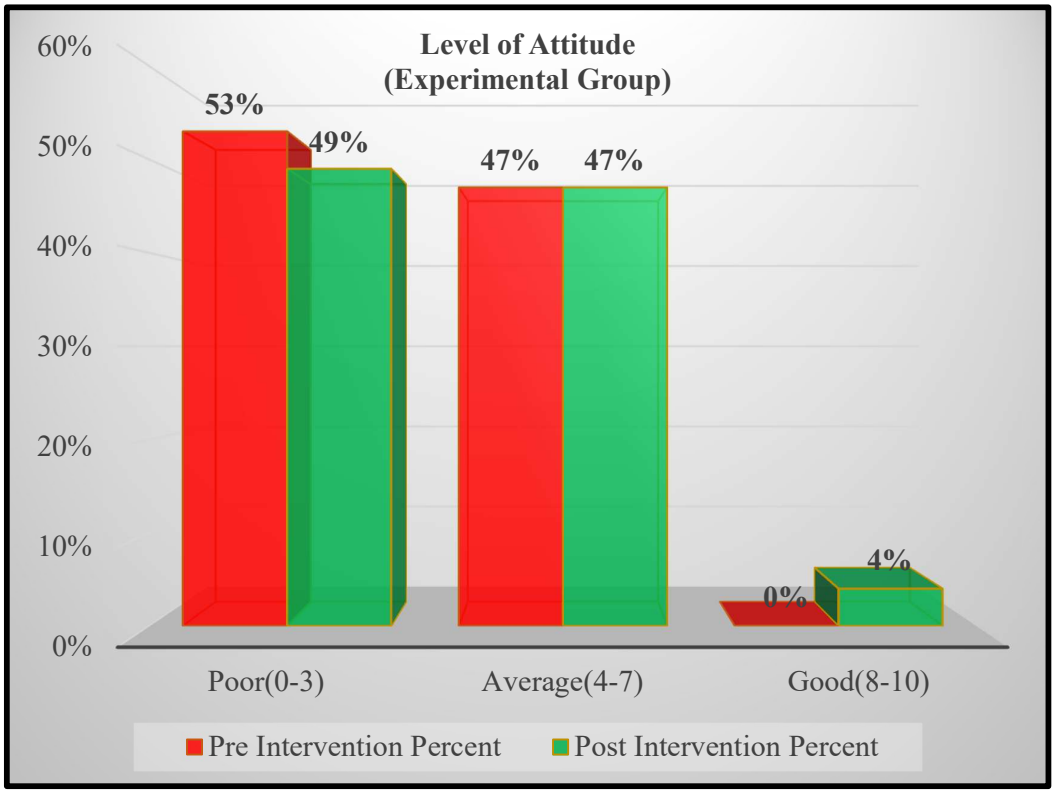

Figure 10. Level of Attitude among the selected subjects in Experimental Group

The questions regarding attitude of selected subjects towards consumption involved both positive attributes to be built and negative attributes to be avoided. A change in attitude was observed among selected subjects post intervention. Many of the selected subjects were found to avoid negative attitude towards consumption of foods and improved positive attitudes post nutritional education impartment. The per cent of poorly nutritionally informed selected subjects came down from 53 per cent to 49 per cent post intervention. There was no change in per cent in average level in pre and post nutrition intervention.

There was a change in selected subjects from none to four per cent in subjects belonging to good level.

4.4.1.4.Effect of Nutrition Education on Attitude towards Nutritional concepts among the selected subjects in Control Group

Table XLII shows the results of effect of nutrition education module on Attitude of the selected subjects in Control Group for pre and post nutrition intervention for the period of three months.

Table XLII. Effect of Nutrition education on Attitude of the selected subjects in Control Group

Questions	Pre-Intervention		Post-Intervention	
	Frequency (n=250)	Per cent (%)	Frequency (n=250)	Per cent (%)
Skipping any meal of the day	114	46	100	40
Preference for drinking boiled water	21	8	30	12
Consumption of breakfast everyday	180	72	186	74
Preference for drinking protein shakes	71	28	65	26
Stress Eating	72	29	67	27
Consumption of raw vegetables and fruits	75	30	82	33
Consumption of Sprouts	82	33	90	36
Consumption of Instant foods(Instant Upma, Biryani etc)	59	24	56	22
Change in lifestyle can bring down occurrence of diseases	54	22	62	25
Malnutrition is always associated only with under nutrition	76	30	70	28

The result of the effect of nutrition education on attitude of the selected subjects in the control group presents that there was a slight change in the attitude of the selected subjects in the control group. The results of depicted that 40 per cent of the selected subjects still skipped a meal which was 46 per cent of selected subjects before nutrition education. 12 per cent of the selected subjects preferred drinking boiled water over eight per cent selected subjects after nutrition education. The consumption of breakfast everyday was improved from 72 per cent to 74 per cent. The preference of the selected subjects on consuming protein shake went down from 28 per cent to 26 per cent. The stress eating in the selected subjects was down to 27 per cent from 29 per cent. The selected subjects

consuming raw vegetables and fruits had gone to 33 per cent from 30 per cent. The preference of the selected subjects consuming has improved from 33 per cent to 36 per cent. The selected subjects' preference for consuming instant food has reduced from 24 per cent to 22 per cent. 25 per cent of the selected subjects understood that a change in lifestyle can bring down the occurrence of disease which was 22 per cent in pre nutrition education. 28 per cent of the selected subjects understood that there are different types of malnutrition and over nutrition can also be termed as malnutrition.

The mean and standard deviation of pre and post nutrition education on Attitude of selected subjects in Control group was carried out in SPSS. By conclusion the mean and standard deviation of pre and post nutrition education on Attitude of selected subjects in Control group was 2.29± 1.31 and 2.34±1.31 respectively. There was no significant change in the mean pre and post intervention values. Figure 11 depicts the Level of Attitude among the selected subjects in Control group.

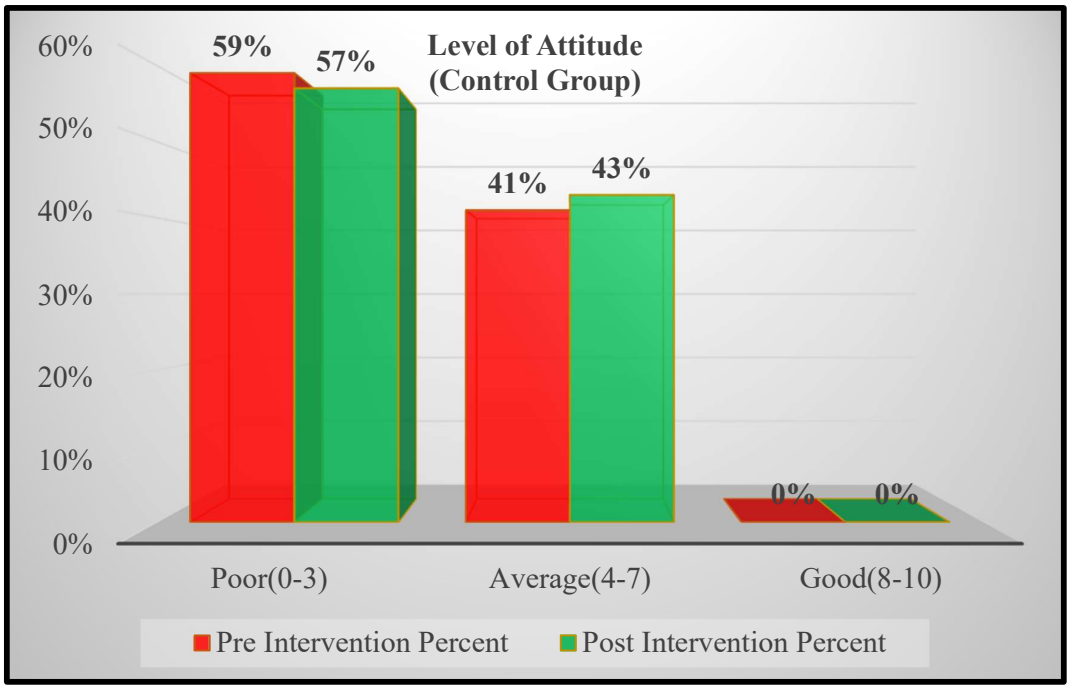

Figure 11. Level of Attitude among the selected subjects in Control Group

The questions regarding attitude of selected subjects towards consumption involved both positive attributes to be built and negative attributes to be avoided. A change in attitude was observed among selected subjects post intervention. The selected subjects were found to avoid negative attitude towards consumption of healthy foods and improved positive attitudes due to nutritional education impartment.

4.4.1.5.Effect of Nutrition Education on Practice adopted towards Nutritional concepts among the selected subjects in Experimental Group

The final component of a KAP study focuses on practice. Researchers can identify gaps between knowledge and action by assessing actual dietary practices and habits among young adult women. This information is crucial in designing effective nutrition education programs that promote sustainable change in their practices towards the dietary habits. The practice is the supreme importance of any nutrition education. The fruit of nutrition education is the application of those teachings in selected subjects' day to day activity and are discussed in the following paper. The result of the effect of Nutrition Education on Practice adopted by the selected subjects in the Experimental group is shown in Table XLIII.

Table XLIII. Effect of Nutrition education on Practice adopted by selected subjects in Experimental Group

Questions	Pre Intervention		Post Intervention	
	Frequency (n=250)	Per cent (%)	Frequency (n=250)	Per cent (%)
Preference for eating in restaurant more frequently	54	22	50	20
Preference for consuming probiotic products	22	9	25	10
Consumption of multivitamin tablets	27	11	21	8
Consumption of flax seeds to cure period's cramps	60	24	63	25
Binge eating	87	35	76	30
Following a diet prescribed by a dietician	79	32	108	43
Exercise for healthy living	65	26	86	34
Nutrition Intervention will promotes healthy living	81	32	91	36
Consumption of junk foods	96	39	87	35
Skipping of food to reduces body weight	51	20	39	16

Table XLIII depicts the change in the practices after the nutrition intervention to the selected subjects in the Experimental Group. There was change in frequent visit to restaurants from 22 per cent to 20 per cent. The preference for consumption of probiotics changed from nine per cent to 10 per cent. This change in preference in consumption of probiotics is as the result of nutrition intervention. The shift in the consumption of multivitamin tablets instead of food moved from 11 per cent to eight per cent. The practice of consumption of flax seeds to cure period's cramps has moved to 24 per cent to 25 per cent. The selected subjects were provided with knowledge on the health benefits of flax seeds. The urge of the selected subjects to binge eat was shifted from 35 per cent to 30 per cent. The selected subjects were made aware during the nutrition education that binge eating is an eating disorder. The preference of acceptance of diet from dietician has changed from 32 per cent to 43 per cent. Health is always associated with healthy diet and exercise. The preference of the selected subjects to follow an exercise routine to keep themselves healthy has changed from 26 per cent to 34 per cent. The belief in nutrition intervention can bring a change in health has moved to 36 per cent from 32 per cent. The preference for consuming junk food has reduced to 35 per cent from 39 per cent. The habit of skipping a meal to control weight has changed to 16 per cent from 20 per cent. There is no noticeable change in selected subjects related to the practices they follow even after the nutrition intervention. It might be due to the short-term intervention. Long term intervention may be helpful for sustainable measures to maintain health status.

There are several studies on the practice of nutritional knowledge in Experimental Group. One study found that virtual-based nutritional interventions helped the Experimental Group selected subjects improve their overall knowledge about the importance of nutrition. A study on non-academic staff in Ghana found that nutrition knowledge and dietary practices influenced their nutritional status (Vasanthakumari *et al.,* 2023) and (Issahaku and Alhassan, 2021).

The mean and standard deviation of pre and post nutrition education on Practice of selected subjects in Experimental group was carried out in SPSS. By conclusion the mean and standard deviation of pre and post nutrition education on Practice of selected subjects in Experimental group was 2.50± 1.26 and 2.61±1.23 respectively. There was no significant change in the mean pre and post intervention values. Figure 12 depicts the Level of Practice among the selected subjects in Experimental group.

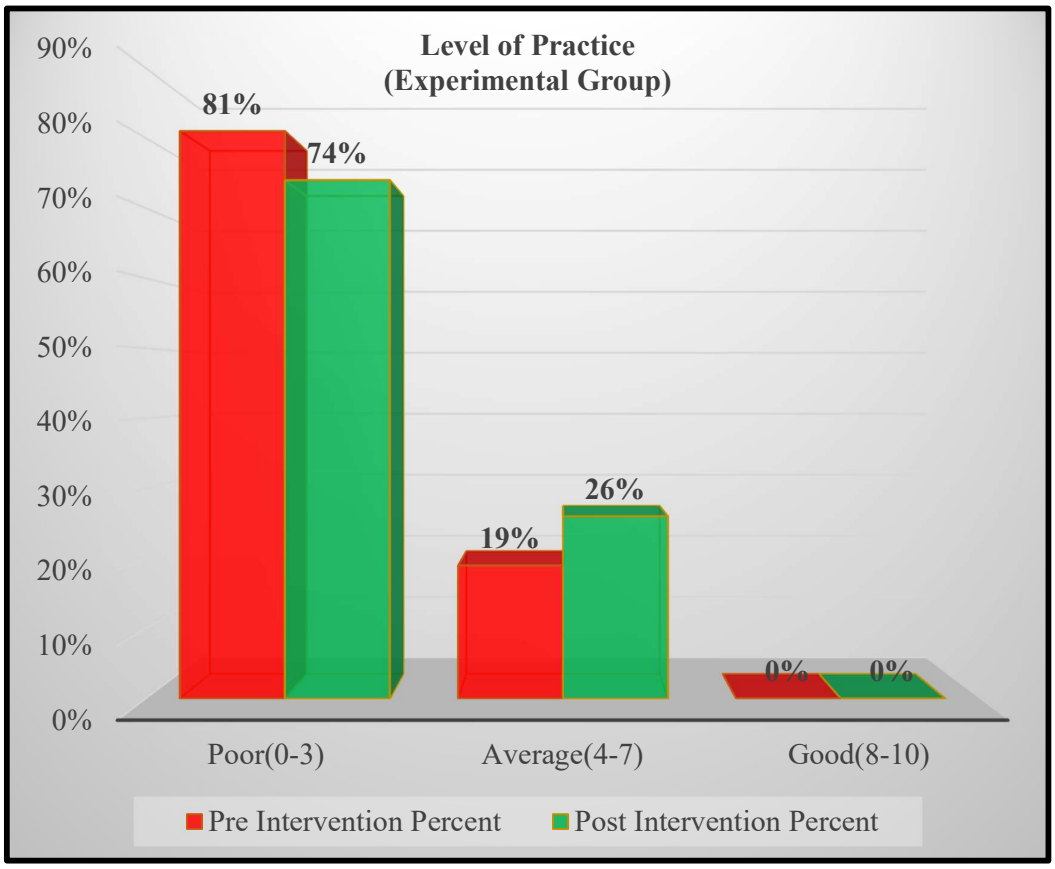

Figure 12. Level of Practice among the selected subjects in Experimental Group

The questions regarding practice of selected subjects towards consumption involved both positive attributes to be built and negative attributes to be avoided. A change in behaviour was observed among selected subjects post intervention. The selected subjects were found to avoid negative practices and improved positive practices post nutritional education impartment.

4.4.1.6.Effect of Nutrition Education on Practice adopted towards Nutritional concepts among the selected subjects in Control Group

The result of the effect of Nutrition Education on Practice adopted by the selected subjects in the Control group is shown in Table XLIV

Table XLIV. Effect of Nutrition education on Practice adopted by selected subjects in Control Group

Questions	Pre Intervention		Post Intervention	
	Frequency (n=250)	Per cent (%)	Frequency (n=250)	Per cent (%)
Preference for eating in restaurant more frequently	78	31	61	24
Preference for consuming probiotic products	17	7	21	8
Consumption of multivitamin tablets	18	7	13	5
Consumption of flax seeds to cure period's cramps	58	23	69	28
Binge eating	78	31	54	22
Following a diet prescribed by a dietician	75	30	81	32
Exercise for healthy living	73	29	87	35
Nutrition Intervention will promotes healthy living	51	20	61	24
Consumption of junk foods	86	34	72	29
Skipping of food reduces body weight	48	19	40	16

Table XLIV depicts the changes in practice which was observed in the selected subjects of Control group. The preference of consuming food in restaurants frequently was reduced to 24 per cent from 31 per cent. The preference of consumption of probiotic products has improved from seven per cent to eight per cent. The consumption of multivitamin tablets changed to five per cent from seven per cent. The consumption of flax seeds to root out periods cramps moved to 28 per cent from 23 per cent. The process of binge eating was reduced to 22 per cent from 31 per cent. The preference to follow a diet prescribed by dietician changed from 30 per cent to 32 per cent. The selected subjects positively responded to their preference to follow an exercise to keep up their health and the per cent changed from 29 per cent to 35 per cent. The belief of selected subjects that a

nutrition intervention can bring out a change in health has changed from 20 per cent to 24 per cent. The consumption of Junk food was reduced from 34 per cent to 29 per cent. The practice of skipping meal to maintain the weight has reduced from 19 per cent to 16 per cent.

The mean and standard deviation of pre and post nutrition education on Practice followed by the selected subjects in Experimental group was carried out in SPSS. By conclusion the mean and standard deviation of pre and post nutrition education on Practice of selected subjects in Experimental group was 2.00± 1.03 and 2.01±1.00 respectively. There was no significant change in the mean pre and post intervention values. Figure 13 depicts the Level of Practice among the selected subjects in Control group.

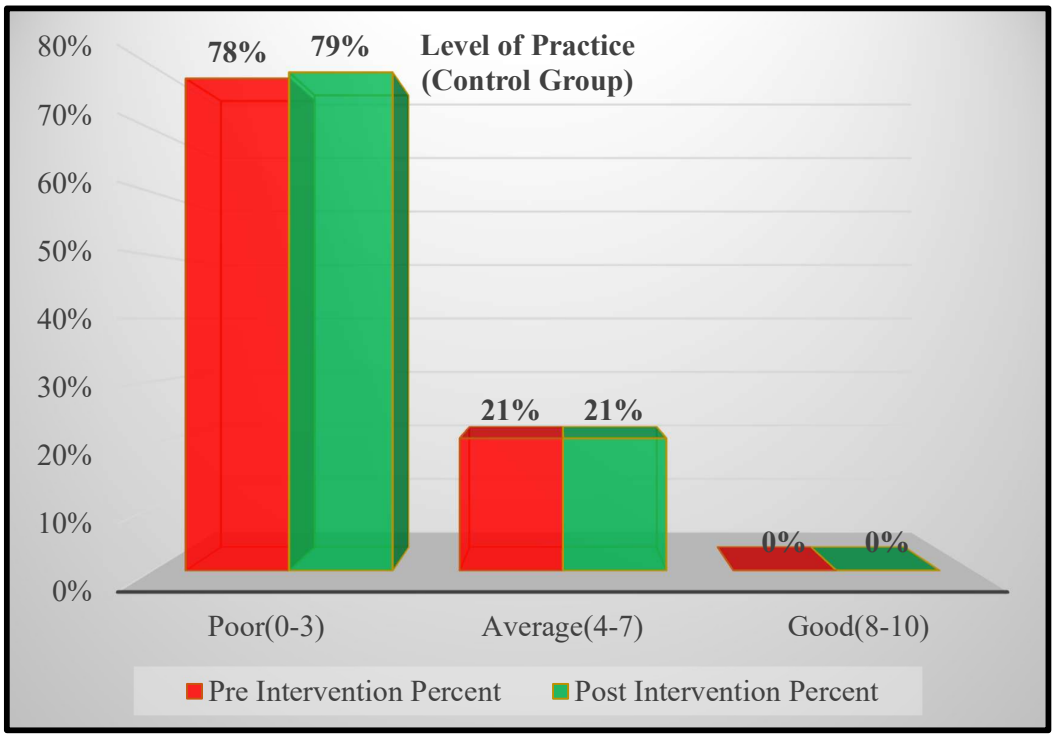

Figure 13. Level of Practice among the selected subjects in Control Group

The questions regarding practice of selected subjects towards consumption involved both positive attributes to be built and negative attributes to be avoided. A change in behaviour was observed among selected subjects post intervention. The selected subjects were found to avoid negative practices and improved positive practices post nutritional education impartment for promotion of health, prevention of ill health and fostering sustainable food system.

4.4.1.7.Effect of Nutrition Education on Knowledge, Attitude and Practice of selected subjects in Experimental and Control Group

The effect of Nutrition Education on Knowledge, Attitude and Practice of selected subjects in Experimental and Control Group was studied using Paired sample t-test and Independent sample t-test in SPSS. Table XLV represents the effect of Nutrition intervention on Knowledge, Attitude and Practice (KAP) of the selected subjects in Experimental and Control Group.

Table XLV. Effect of Nutrition Intervention on KAP study among the study groups

Parameter	Groups	Mean ± SD	t value	p value
Knowledge	Within Experimental Group	1.32±0.036	3.771	0.004*
	Within Control Group	0.166±0.015	1.897	0.223
	Mean difference Between Expt and Cont group post values	1.167	1.988	0.056
Attitude	Within Experimental Group	1.26±0.011	1.667	0.024*
	Within Control Group	0.100±0.012	1.332	0.198
	Mean difference Between Expt and Cont group post values	1.178	1.987	0.066
Practice	Within Experimental Group	0.167±0.016	2.998	0.136
	Within Control Group	0.170±0.015	1.664	0.223
	Mean difference Between Expt and Cont group post values	1.177	1.988	0.056

*Significant at 0.05 level

The results of the KAP study was further analysed by diving it in to Knowledge, Attitude and Practice where the selected subjects were accessed for the score they obtained during the KAP study. The mean value for Knowledge within Experimental group was 1.32±0.036 and within Control group was 0.166±0.015. The mean difference between Experimental and Control group post values for Knowledge was 1.167. The mean value for Attitude within Experimental group is 1.26±0.011 and within Control group was 0.100±0.012. The mean difference between Experimental and Control group post values for

Attitude was 1.178. The mean value for Practice within Experimental group was 0.167±0.016 and within Control group was 0.170±0.015. The mean difference between Experimental and Control group post values for Practice was 1.177. The p value of Knowledge level within Experimental group was 0.004 and within Control group was 0.223. The p value for Attitude level within Experimental group was 0.024 and within Control group was 0.198. In case of the Practice level within Experimental group, the p value was 0.136 and within Control group the p value was 0.223. There was a significant effect in the selected subjects in Experimental group for Knowledge and Attitude as the p value is less than 0.05. There was no significant effect on the selected subjects in Experimental or Control group as the p value is more than 0.05. The p value for Knowledge between Experimental and Control group post values was 0.056. The p value for Attitude between Experimental and Control group post values was 0.066. The p value for Practice between Experimental and control group post values was 0.056. There was no significant difference between Experimental and Control group post values with Knowledge, Attitude and Practice of selected subjects.

In a study by Mukhamedzhano *et al.,* (2023), researchers find that Experimental groups exhibit significant improvements in nutritional attitudes and behaviours relative to control groups after receiving a specific nutrition education program or intervention. However, it is essential to note that not every study finds statistically significant differences in nutritional attitudes and behaviours between Experimental and control groups. Factors like the quality of the intervention, participant motivation, and the strength of the control group design contribute to the success of observing changes in nutritional attitudes within Experimental groups.

Nutrition education interventions have demonstrated significant benefits for college girls, particularly regarding improvements in nutrition knowledge, self-efficacy, and dietary behaviour. Studies show that female college students are highly motivated to learn about nutrition and maintain better health compared to their male peers. Specifically, nutrition education interventions combining lecture formats, web-based education, and supplement provision have led to enhanced dietary habits, daily nutrient intake, and quality of life and the same trend was noted in the study conducted by Dhandevi and Jeewon (2015).

Another systematic review highlighted that maternal nutrition education positively affects children's nutritional status, with improved maternal knowledge and practices linked to better birth weights and overall health outcomes for children (Prasetyo *et al.,* 2023).

In conclusion, conducting a KAP study among young adult women provided valuable insights into their knowledge levels about nutrition, attitudes towards healthy eating habits, and actual dietary behaviours. This information serves as a foundation for developing targeted interventions that empower this demographic to make informed choices for their overall well-being.

4.4.2.Effect of Dietary Intervention on Nutritional Status of Triple Burden of Malnutrition among the selected subjects

Young adult women are susceptible to have more macro and micronutrients surplus or deficiency that include over-weight, under-weight and deficiency diseases of iron, folic acid calcium etc. Food based approach is very effective to enhance the health status of an individual. To assess the effect of dietary intervention on the nutritional status of the selected study subjects, nutritional anthropometric measurements, clinical examination, biochemical estimations and dietary intake were executed and data collected are given in the following pages with statistical analysis.

Statistical analysis plays a crucial role in human nutrition research, particularly in randomized controlled trials (RCTs) focusing on dietary interventions. Developing a statistical analysis plan a priori is essential for transparency, validity, and reproducibility in research. Dietary pattern analysis explores the relationship between diet and health outcomes, considering the complex interplay of various foods and nutrients.

The plan should include clear definitions of variables, procedures for outlier management, handling missing data, and consideration of variable types (scale, nominal, ordinal) In conclusion, a well-defined statistical analysis plan is fundamental for conducting rigorous human nutrition RCTs. Understanding different statistical methods and their implications on dietary pattern analysis is vital for deriving meaningful insights into the relationship between diet and health outcomes (Petersen *et al.,* 2021). Based on this aspect, statistical analysis was carried and are presented in the following pages.

4.4.2.1.Effect of Dietary Intervention on Anthropometric Measurements of the selected subjects

Data collected on various anthropometric measurements of the selected young adult women in the Experimental (Expt.) and Control (Cont.) groups, pre and post Nutrition Interventions for the period of 90 days are given in the following pages.

4.4.2.1.1.Effect of Dietary Intervention on BMI of selected subjects in Experimental and Control groups

The effect of dietary interventions on BMI of the selected subjects in Experiment (Expt.) and Control (Cont.) group was studied using Comparing means, Paired sample t-test and independent sample t-test by SPSS. Table XLVI depicts the effect of dietary intervention on BMI of selected subjects in Experimental and Control groups.

Table XLVI. Effect of Dietary Intervention on BMI of selected subjects in Experimental and Control groups

Dietary Supplements	Groups	Mean ± SD Within Groups			t value	p value
		Pre	Post	Pre & Post		
Nutri Ball (NB3)	Expt. (n=110)	18.262 ±0.140	25.268 ±0.140	1.776 ±1.032	1.336	0.047*
	Cont. (n=110)	18.854 ±1.33	18.77 ±1.33	0.10604 ±0.766	2.338	0.209
Ragi Brownie (RB1)	Expt. (n=45)	18.062 ±0.140	25.068 ±0.140	1.790 ±1.031	1.421	0.046*
	Cont. (n=45)	18.454 ±1.33	18.37 ±1.33	0.1001 ±0.729	2.322	0.22
Sprouts Tikki (ST1)	Expt. (n=95)	27.429 ±1.392	21.313 ±0.16	1.826 ±1.047	2.692	0.021*
	Cont. (n=95)	29.802 ±3.65	29.838 ±2.12	0.40604 ±0.780	3.788	0.110
Mean difference between groups post values						
Nutri Ball (NB3)		3.498			6.996	0.000*
Ragi Brownie (RB1)		3.698			6.879	0.000*
Sprouts Tikki (ST1)		3.792			6.873	0.000*

*Significant at 0.05 level

4.4.2.1.1.1.Nutri Ball (NB3)

The results in Table XLVI illustrated that there was a difference in mean value of BMI of selected subjects in Experimental group which was from 18.262±0.140 to 25.268±0.140.The change in mean value of BMI of the selected subjects in Control group was from 18.854±1.33 to 18.77±1.33 The mean value of BMI between Pre and Post dietary intervention of Experimental group subjects was 1.776±1.032 and mean value of BMI between Pre and Post dietary intervention of Control group was 10604±0.766 .The mean

difference of BMI between Experimental and Control group post values was 3.498. The paired sample t-test which was conducted to assess the effect of dietary intervention on BMI and the results showed that in the selected subjects in Experimental group had a p value 0.047 and t value was 1.336. The p and t value for the control group was 0.209 and 2.338 respectively. The p-value in the Experimental group was $p<0.05$, therefore there is a significant difference between the pre and post dietary intervention values. The p value and t value for independent sample t test was 0.000 and 6.996 respectively. The result depicted that there was an effect of dietary intervention on BMI of selected subjects in experimental group supplemented with Nutri Ball (NB3).

Studies have shown that dietary interventions can lead to improvements in BMI and BMI z-scores. A meta-analysis of randomized controlled trials found that children who received dietary interventions had a greater reduction in BMI compared to usual care. It is important to note that while some studies have shown positive effects of dietary interventions on BMI (Long *et al.,* 2021). The same trend was seen in the current research study.

4.4.2.1.1.2.Ragi Brownie (RB1)

The results in Table XLVI illustrates that there was a difference in mean value of BMI of selected subjects in Experimental group which was from 18.062±0.140to 25.068±0.140. The change in mean value of BMI of the selected subjects Control group was from 18.454±1.33 to 18.37±1.33. The mean value of BMI between Pre and Post dietary intervention of Experiment group was 1.790±1.031 and mean value of BMI between Pre and Post dietary intervention of Control group was 0.1001±0.729.The mean difference of BMI for between Experimental and Control group post values was 3.698. The paired sample t-test which was conducted to assess the effect of dietary intervention on BMI and the results shows that in the selected subjects in Experimental group had a p value 0.046 and t value was 1.421. The p value for the control group was p =0.22and t=2.322. The p-value in the Experimental group was $p<0.05$, therefore there is a significant difference between the pre and post dietary intervention values. The p value and t value for independent sample t test was 0.000 and 6.879 respectively. The result depicted that there was an effect of dietary intervention on BMI of selected subjects in experimental group supplemented with Ragi Brownie (RB1).

Under nutrition is a pervasive global health problem with consequences for survival, healthy development, and the economic productivity of individuals and societies. Women of reproductive age, especially in low- and middle-income countries, carry a

disproportionate and inequitable burden of malnutrition due to physiological, sociocultural, and economic mechanisms (Riddle *et al.,* 2021). In some regions, most women are underweight, and stunting is a known risk factor for obstetric complications such as obstructed labour and the need for skilled intervention leading to injury or death for mothers and their new-borns (Vir, 2016).

4.4.2.1.1.3.Sprouts Tikki (ST1)

The results in Table XLVI illustrates that there was a difference in mean value of BMI of selected subjects in Experimental group which was from 27.429±1.392 and it reduced to 21.313±0.16. In the case of Control group , mean value of BMI has moved from 29.802±3.65 to 29.838±2.12. The mean value of BMI between Pre and Post dietary intervention Experimental group was 1.826±1.047 and mean value of BMI between Pre and Post dietary intervention of Control group was 0.40604±0.780. The mean difference of BMI between Experimental and Control group post values was 3.792. The paired sample t-test which was conducted to assess the effect of dietary intervention on BMI and the results shows that in the selected subjects in Experimental group had a p value 0.021 and t value was 2.092. The p value for the control group was p =0.110 and t=3.788. The p-value in the Experimental group is $p<0.05$, therefore there is a significant difference between the pre and post dietary intervention values. The p value and t value for independent sample t test was 0.00 and 6.873 respectively. The result depicted that there was an effect of dietary intervention on BMI of selected subjects in experimental group supplemented with Sprouts Tikki (ST1).

A randomized controlled trial found that personalized nutrition intervention improved health status in overweight/obese Chinese adults, leading to a decrease in BMI, body fat percentage, and waist circumference (Kan *et al.,* 2022).

A systematic review found that dietary treatments led to improved metabolic indicators, including reductions in fasting glucose and lipid levels, alongside notable weight loss in women with obesity. Additionally, studies have shown that structured dietary plans, often combined with behavioural modifications, can effectively reduce BMI, with some interventions resulting in a decrease of approximately 10per cent in weight among participants (Chen *et al.,* 2022).

Dietary interventions play a vital role in managing overweight in women. Research indicates that dietary strategies form the foundation of obesity management and treatment (Adeola *et al.,* 2023). For instance, nutrition interventions have led to improvements in diet quality, reductions in fat consumption, and increases in beneficial vitamin and mineral

intake, ultimately benefiting health status in overweight/obese individuals (Kan *et al.,* 2022).

4.4.2.1.2.Effect of Dietary Interventions on WHR of selected subjects in Experimental and Control groups

The effect of Dietary Interventions on the WHR of the selected subjects in Experiment and Control group was studied using Comparing means, Paired sample t test and Independent sample t test by SPSS. Table XLVII depicts the effect of dietary intervention on WHR of selected subjects in Experimental (Expt.) and Control (Cont.) groups.

Table XLVII. Effect of Dietary Intervention on WHR of selected subjects in Experimental and Control groups

Dietary Supplements	Groups	Mean ± SD Within Groups			t value	p value
		Pre	Post	Pre & Post		
Nutri Ball (NB3)	Expt. (n=110)	0.7570 ±0.02	0.7570 ±0.31	0.010 ±0.027	4.733	0.113
	Cont. (n=110)	0.7770 ±0.132	0.7770 ±0.238	0.0101 ±0.023	3.998	0.349
Ragi Brownie (RB1)	Expt. (n=45)	0.746 ±0.02	0.746 ±0.31	0.010 ±0.0231	4.592	0.101
	Cont. (n=45)	0.778 ±0.132	0.779 ±0.238	0.0140 ±0.0231	2.289	0.349
Sprouts Tikki (ST1)	Expt. (n=95)	0.8779 ±0.027	0.85811 ±0.2	0.0103 ±0.00980	5.587	0.139
	Cont. (n=95)	0.8677 ±0.21	0.8834 ±1.56	0.0104 ±0.012	4.710	0.211
Mean difference between groups post values						
Nutri Ball (NB3)		0.002			3.652	0.059
Ragi Brownie (RB1)		0.010			3.898	0.067
Sprouts Tikki (ST1)		0.001			3.879	0.062

*Significant at 0.05 level

4.4.2.1.2.1.Nutri Ball (NB3)

The results in Table XLVII illustrates that there was a difference in mean value of WHR of selected subjects in Experimental group which was from 0.7570±0.02 to 0.7570±0.31.The change in mean value of WHR of the selected subjects in Control group was from 0.7770±0.132 to 0.7770±0.238. The mean value of WHR between Pre and Post dietary intervention of Experiment group was 0.010±0.027 and mean value of WHR between Pre and Post dietary intervention of Control group was 0.0101±0.023. The mean difference of WHR between Experimental and Control group post values was 0.002. The paired sample t-test which was conducted to assess the impact of dietary intervention on WHR and the results shows that in the selected subjects in Experimental group had a p value 0.113 and t value was 4.733. The p value for the control group was p=0.349 and t=3.998. The change in WHR in both Experimental and Control group was not a prominent value as the p value is more than 0.05. Therefore, the effect of dietary intervention was not beneficial in bringing out an effect on WHR of Experimental and Control group. The p value and t value for independent sample t test was 0.059 and 3.652 respectively. The result depicted that there was no effect of dietary intervention on WHR of selected subjects in experimental group supplemented with Nutri Ball (NB3).

For individuals classified as underweight based on their body mass index (BMI), the waist-to-hip ratio (WHR) is still relevant as a measure of health risk. Although WHR is primarily used to identify excessive abdominal fat, which is associated with metabolic disorders like type 2 diabetes and cardiovascular disease, it can provide additional insights into health risks for underweight individuals. According to the World Health Organization (WHO), a moderately elevated WHR (>0.85 for women and >0.9 for men) is associated with an increased risk of heart disease and other conditions linked to being overweight (Ahmad *et al.,* 2016).

4.4.2.1.2.2.Ragi Brownie (RB1)

The results in Table XLVII illustrates that there was a difference in mean value of WHR of selected subjects in Experimental group which was from 0.746±0.02 to 0.746 ±0.31. The change in mean value of WHR in the selected subjects Control group was from 0.778 ±0.132 to 0.779 ±0.238. The mean value of WHR between Pre and Post dietary

intervention of Experimental group was 0.010±0.0231 and mean value of WHR between Pre and Post dietary intervention of Control group was 0.0140±0.0231. The mean difference of WHR between Experimental and Control group post value was 0.010. The paired sample t-test which was conducted to assess the impact of dietary intervention on WHR and the results shows that in the selected subjects in Experimental group had a p value 0.101 and t value was 4.592. The p value for the control group was p =0.349 and t=2.289. The change in WHR in both Experimental and Control group was not a prominent value as the p value is more than 0.05. Therefore the effect of dietary intervention was not beneficial in bringing out an effect on WHR of Experimental and Control group. The p value and t value for independent sample t test was 0.067 and 3.898 respectively. The result depicted that there was no effect of dietary intervention on WHR of selected subjects in experimental group supplemented with Ragi Brownie (RB1).

Research shows that adopting dietary patterns rich in fruits, vegetables, whole grains, and low-fat dairy while minimizing red and processed meats can help prevent abdominal fat accumulation, thereby reducing WHR. For instance, a study found that a 12-week caloric restriction program led to notable weight loss and a decrease in WHR among women with obesity, highlighting the effectiveness of structured dietary approaches. Additionally, adherence to energy-restricted diets is closely linked to greater reductions in WHR, emphasizing the importance of behavioural factors in achieving successful outcomes (Chao *et al.,* 2021).

4.4.2.1.2.3.Sprouts Tikki (ST1)

The results in Table XLVII illustrates that there was a difference in mean value of WHR of selected subjects in Experimental group which was from 0.8779±0.027 to 0.85811±0.212. The change in mean value of WHR in the selected subjects in Control group was from 0.86773±0.21 to 0.8834±1.56. The mean value of WHR between Pre and Post dietary intervention of selected subjects in Experimental group was 0.0103±0.00980 and mean value of WHR between Pre and Post dietary intervention of Control group was 0.0104±0.012. The mean difference of WHR between Experimental and Control groups post values was 0.001. The paired sample t-test which was conducted to assess the impact of nutrition intervention on WHR and the results showed that in the selected subjects in Experimental group had a p value 0.139 and t value was 5.587. The p value for the control group was p =0.211 and t=4.710. The change in WHR in both Experimental and Control

groups was not a prominent value as the p value is more than 0.05. Therefore, the effect of dietary intervention was not beneficial in bringing out an effect on WHR of Experimental and Control group. The p value and t value for independent sample t tests were 0.062 and 3.879 respectively. The result depicted that there was no effect of dietary intervention on WHR of selected subjects in experimental group supplemented with Sprouts Tikki (ST1).

Waist-to-hip ratio (WHR) plays an essential role in evaluating health risks related to overweight in women. While body mass index (BMI) is widely used to screen for obesity, WHR provides a more nuanced view of body composition, focusing on the distribution of fat rather than overall weight. Specifically, WHR highlights the amount of visceral fat, which is strongly associated with metabolic disorders and cardiovascular diseases. Studies indicate that WHR is a stronger predictor of morbidity and mortality than BMI, especially among women. Additionally, WHR is more sensitive to changes in body composition, making it a valuable tool for monitoring health status during weight management efforts (Hara, 2020).

4.4.2.2.Effect of Dietary Intervention on Biochemical Profile of the selected subjects

Data collected on Biochemical Profile of the selected young adult women in the Experimental (Expt.) and Control (Cont.) groups, pre and post Nutrition Interventions for the period of 90 days are given in the following pages.

4.4.2.2.1.Effect of Dietary Interventions on Biochemical Profile of selected subjects in Experimental and Control groups

The effect of dietary interventions on the Biochemical Profile of selected subjects in Experimental (Expt.) and Control (Cont.) groups with Triple Burden of Malnutrition was studied using Comparing means, Paired sample t test and Independent sample t test by SPSS. The Table XLVIII depicts the effect of dietary intervention on biochemical profile of selected subjects in Experimental and Control groups.

Table XLVIII. Effect of Dietary Intervention on Biochemical profile of selected subjects in Experimental and Control groups

Dietary Supple-ments	Parameters	Groups	Mean±SD Within Groups			t value	p value
			Pre	Post	Pre & Post		
Nutri Ball (NB3)	Serum Iron (µg)	Expt. (n=50)	41.876 ±4.976	88.486 ±2.463	44.590 ±21.096	9.998	0.026*
		Cont. (n=50)	33.928 ±7.990	33.936 ±7.993	0.698 ±2.574	2.296	0.376
Ragi Brownie (RB1)	Serum Calcium (mg)	Expt. (n=45)	6.794 ±1.013	8.2796 ±1.010	2.197 ±2.5778	8.82	0.039*
		Cont. (n=45)	6.995 ±0.556	7.231 ±0.7185	1.445 ±0.768	2.296	0.126
Sprouts Tikki (ST1)	Serum Folic Acid (ng)	Expt. (n=57)	3.135 ±0.522	4.635 ±1.981	1.4826 ±2.007	5.575	0.041*
		Cont. (n=57)	2.696 ±0.694	2.907 ±0.6702	0.210 ±0.486	3.267	0.133
Mean difference between groups post values							
Nutri Ball (NB3)			53.234			11.459	0.000*
Ragi Brownie (RB1)			1.787			6.989	0.000*
Sprouts Tikki (ST1)			1.9386			6.996	0.000*

*Significant at 0.05 level

The change in serum iron, serum calcium and serum folic acid as an effect of dietary intervention on biochemical profile of the selected subjects in Experimental (Expt.) and Control (Cont.) groups supplemented with Nutri Ball (NB3), Ragi Brownie (RB1) and Sprouts Tikki (ST1) are described in Table XLVIII.

4.4.2.2.1.1.Nutri Ball (NB3)

In case of improving the serum iron status in blood, dietary intervention had a great effect as the presence of serum iron raised from 41.876±4.976 to 88.486±32.463 in Experimental group. There was no appreciable improvement in Control group with respect to serum iron status as the change was from 33.928±7.990 to 33.93600±7.993. The mean value of serum iron between Pre and Post dietary intervention of Experimental group was 44.590±21.096 and mean value of serum iron between Pre and Post dietary intervention of Control group was 0.698±2.574. The mean difference of serum iron between Experimental and Control groups post value was 53.234. The paired sample t-test which was conducted to assess the effect of dietary intervention on serum iron and the results showed that the selected subjects in Experimental group had p value 0.026 and t value was 9.998. The p value for the control group was p =0.376 and t=2.296. The p value is less than 0.05, therefore there is a significant difference in serum iron level in Experimental group. The p value and t value for independent sample t test was 0.000 and 11.459 respectively.

In a study on young women, it was found that dietary intervention with iron and vitamin C administered separately can effectively improve iron status. The study showed that long-lasting dietary interventions are needed to observe significant improvements in hematocrit and ferritin levels, with increased levels seen after 8 weeks of intervention (Skolmowska and Głąbska, 2022). The systematic review and meta-analysis confirmed that iron supplementation improved iron status (Casgrain *et al.,* 2012).

A systematic review focused on treating iron-deficiency anaemia in women through dietary interventions. The review highlighted the importance of increasing iron intake and absorption to address anaemia effectively. Various dietary interventions were assessed, emphasizing the role of dietary strategies in managing iron-deficiency anaemia (Skolmowska *et al.,* 2022). In the present study, dietary intervention increased serum iron level.

4.4.2.2.1.2.Ragi Brownie (RB1)

The mean value of serum calcium in Experimental group moved from 6.794±1.013 to 8.2796±1.010 and in Control group it moved from 6.995±0.556 to 7.231±0.7185. There was a change in serum calcium in both Experimental and Control group but it was prominent in Experimental Group. The mean value of serum calcium between Pre and Post dietary

intervention of Experimental group was 2.197±2.5778 and mean value of serum calcium between Pre and Post dietary intervention of Control group was 1.445±0.768. The mean difference of serum calcium between Experimental and Control groups post values was 1.787. The paired sample t-test which was conducted to assess the effect of dietary intervention on serum calcium and the results showed that in the selected subjects in Experimental group had a p value 0.039 and t value was 8.82. The p value for the control group was p =0.126 and t=2.296. The p value is less than 0.05, therefore there is a significant difference in serum calcium level in Experimental group. The p value and t value for independent sample t test was 0.000 and 6.989 respectively.

Studies indicate that the calcium from ragi is better absorbed in the digestive tract compared to other grains, despite its higher content of phytates and oxalates, which typically inhibit calcium absorption (Anitha *et al.,* 2021).

Studies have indicated that adult women's serum calcium levels and bone mineral density can be raised by exercise and diet supplements containing finger millet (Sahaya Rani *et al.,* 2021). Finger millet has an extraordinary calcium content which is eight times more than other cereals and millets when compared to other grains. It has high levels of iron and phosphorus, as well as a variety of vitamins and trace minerals. Finger millet has a high potassium content that makes it superior to other cereals and millets. It has been found that the finger millet variety known as "Hamsa" has 660 mg of calcium, which is significantly more than any other variation (Kushwaha and Singh, 2023). In current study, inclusion of ragi helped to increase the calcium content of the developed supplements.

4.4.2.2.1.3.Sprouts Tikki (ST1)

The mean value of serum folic acid had raised to 4.635±1.981 from 3.135±0.522 in Experimental Group and in control group it had raised to 2.907±0.6702 from 2.696±0.694. The mean value of serum folic acid between Pre and Post dietary intervention of Experimental group was 1.4826±2.007 and mean value of serum folic acid between Pre and Post Nutrition Intervention of Control group was 0.210±0.486. The mean difference of serum folic acid between Experimental and Control groups post values was 1.9386. The paired sample t-test which was conducted to assess the impact of dietary intervention on serum folic acid and the results showed that in the selected subjects the Experimental group had a p value 0.041and t value was 5.575. The p value for the control group was p =0.133

and t=3.267. The p value is less than 0.05, therefore there is a significant difference in serum folic acid level in Experimental group. The p value and t value for independent sample t test was 0.000 and 6.996 respectively.

Sprouts Tikki developed from Whole Bengal Gram was prepared for supplementing the selected subjects with folic Acid deficiency. Bengal gram is a type of legume that is rich in nutrients, including folic acid. Folic acid is important for the production and maintenance of new cells, especially red blood cells, and helps in brain development and preventing DNA changes that might cause cancer. Bengal gram's naturally rich folate content can help to prevent the risk of birth defects in the foetus's brain and spinal cord (Jha, *et al.,* 2015). The health benefits of Bengal gram was used for the development of Sprouts Tikki and the effect of dietary supplementation had an effect.

The increment in serum iron, serum calcium and serum folic acid level in Experimental group might be due to the dietary intervention which included both Nutrition Education as well as Dietary Supplementation which was not provided to Control group. The Control group was provided with only an awareness about various aspects of Nutrition and its effect on health.

4.4.2.3.Effect of Dietary Intervention on Clinical Profile and Health problems of the selected subjects

Data collected on Clinical Profile and Health problems of the selected young adult women in the Experimental (Expt.) and Control (Cont.) groups, pre and post Nutrition Interventions for the period of 90 days are given in the following pages.

4.4.2.3.1.Effect of Dietary Intervention on Clinical Profile and Health problems of selected subjects in Experimental and Control groups

The effect of Dietary Interventions on the Clinical Profile and Health problems of selected subjects in Experimental (Expt.) and Control (Cont.) group with Triple Burden of Malnutrition was studied using paired sample t-test and Independent sample t-test by SPSS. Table XLIX depicts the effect of Dietary Intervention on incidence of signs and symptoms for various health problems among the selected subjects in Experimental and Control groups. Table L depicts the result of t-test on Clinical Profile and Health problems of the selected subjects in Experimental and Control group with Triple Burden of Malnutrition.

Table XLIX. Effect of Dietary Intervention on incidence of Signs and Symptoms for various health problems among the selected subjects in Experimental and Control groups

Signs and Symptoms experienced	Sprout Tikki (ST1)				Ragi Brownie (RB1)				Nutri Ball (NB3)			
	Expt. n=95		Cont. n=95		Expt. n=45		Cont. n=45		Expt. n=110		Cont. n=110	
	Pre (%)	Post (%)	Pre (%)	Post (%)	Pre (%)	Post (%)	Pre (%)	Post (%)	Pre (%)	Post (%)	Pre (%)	Post (%)
Pallor (Conjunctiva, Palms, Nail Beds, Tongue)	1.2	1.2	1.2	1.2	0.4	0.4	0.4	0.4	2.4	2.3	0.8	0.8
Fatigue	1.2	1.0	1.6	1.5	2.0	1.8	1.2	1.2	7.2	6.7	4.0	4.0
Bowel Movement	4.4	3.9	2.8	2.9	3.2	3.0	2.8	2.8	4.8	4.5	3.2	3.3
Menstrual Irregularities	3.6	3.2	1.6	1.5	4.0	3.7	2.8	2.8	7.2	6.4	3.6	3.6
Visual problems	4.0	4.0	1.6	1.6	3.2	3.2	1.6	1.6	6.8	6.8	1.6	1.6
Hair Loss	11.6	11.3	3.6	3.6	6.4	6.4	2.0	2.0	5.2	5.2	4.0	4.0

4.4.2.3.1.1.Nutri Ball (NB3)

The results of effect of dietary intervention on signs and symptoms shows that in the selected subjects in Experimental group, there was slight improvement in the selected subjects with Pallor (Conjunctiva, Palms, Nail Beds, Tongue) where signs had come down to 2.3 per cent subjects from has come down 2.4 per cent in Experimental group. There was

slight improvement in signs and symptoms for fatigue where it had moved to 6.7 per cent subjects from 7.2 per cent subjects in Experimental group. There was also an improvement in menstrual irregularities from 7.2 per cent subjects to 6.4 per cent subjects in selected subjects in Experimental group.

4.4.2.3.1.2.Ragi Brownie (RB1)

The results with Ragi Brownie states that there was slight improvement in signs and symptoms of Fatigue, Bowel Movement and Menstrual Irregularities in Experimental group. The improvement in Fatigue was from 2.0 per cent subjects to 1.8 per cent subjects, in Bowel Movement was from 3.2 per cent subjects to 3.0 per cent subjects and Menstrual Irregularities was from 4 per cent subjects to 3.7 per cent subjects.

4.4.2.3.1.3.Sprouts Tikki (ST1)

There was very slight improvement in signs and symptoms of Bowel Movement, Menstrual Irregularities and Hair loss in Experimental group. The results shows that the improvement was from 4.4 to 3.9 per cent selected subjects with Bowel Movement, the improvement was from 3.6 to 3.2 per cent selected subjects with Menstrual Irregularities and the improvement was from 11.6to 11.3per cent selected subjects with Hair loss.

Table L. Effect of Dietary Intervention on Clinical Profile and Health problems of selected subjects in Experimental and Control groups

Parameter	Groups	Mean ± SD	t value	p value
Signs and Symptoms for various disease	Within Experiment Group (n=250)	1.004±0.021	5.733	0.211
	Within Control Group (n=250)	0.10±0.011	3.908	0.349
	Mean difference between groups post values	0.167	0.988	0.077

*Significant at 0.05 level

The results for Clinical signs and symptoms show that the mean value with in the Experiment Group was 1.004±0.021 and Control Group was 0.10±0.011 and mean difference between groups post values was 0.167. There was no evident change with the Clinical signs and symptoms as the p value for this parameter is 0.211 for Experimental group and 0.349 for Control group. The p value in both Experimental and Control group is more than 0.05. Therefore there is no significance difference. The results depicted that there is no significant effect on clinical signs and symptoms of both Experimental and Control group. The p value and t value for independent sample t test was 0.077 and 0.988 respectively.

Clinical symptoms are important in malnutrition as they can help identify the condition. The main symptom of malnutrition is unintentional weight loss, although this is not always obvious. Other symptoms of malnutrition include reduced appetite, lack of interest in food and drink, feeling tired all the time, feeling weaker, getting ill often and taking a long time to recover, wounds taking a long time to heal, poor concentration, feeling cold most of the time, low mood, sadness, and depression. Malnutrition can result from unsuitable dietary choices, low income, difficulty obtaining food, or various health conditions (Cheah and Illsley, 2020).

4.4.2.4.Effect of Dietary Intervention on Dietary Intake of the selected subjects

Data collected on Dietary Intake of the selected young adult women in the Experimental (Expt.) and Control (Cont.) groups, pre and post Nutrition Interventions for the period of 90 days are given in the following pages.

4.4.2.4.1.Effect of Dietary Intervention on Dietary Intake of selected subjects in Experimental and Control groups

The effect of Dietary Intervention on the Dietary Intake of selected subjects in Experimental (Expt.) and Control (Cont.) groups with Triple Burden of Malnutrition was studied by comparing means using SPSS. Table LI shows the 24 hour Recall method of the Experimental and Control groups, before and after Dietary Intervention.

Table LI. Effect of Dietary Intervention on 24 hour recall of selected subjects in Experimental and Control groups

Nutrients	ICMR RDA (2020)	Experimental Group(n=250) Mean±SD			Control Group(n=250) Mean±SD		
		Pre	Post	Mean diff.	Pre	Post	Mean diff.
Energy (Kcal)	1645	1871.05 ±180	1893.05 ±186	21.95	1888.07 ±193	1891.2 ±193	3.13
Carbohydrate (g)	130	154.14 ±33.4	149.02 ±42.9	-5.12	165.01 ±54.8	165.01 ±44.9	0
Protein (g)	45.7	36.48 ±28.1	36.54 ±28.15	0.06	36.57 ±26.02	40.33 ±26.9	3.76
Fat (g)	20	18.71 ±11.2	11.02 ±13.6	-7.69	10.12 ±17.4	10.01 ±19.2	-0.11
Calcium (mg)	1000	614.6 ±268.4	633.1 ±204.4	18.5	701.5 ±233.1	655.1 ±204.4	-46.4
Iron (mg)	29	17.204 ±5.22	21.144 ±3.14	3.94	23.678 ±9.16	23.13 ±0.14	-0.548
Folic Acid (µg)	220	163.99 ±34.3	168.31 ±30.3	4.32	154.22 ± 98.5	155.3 ±33.3	1.08
Vitamin C (mg)	65	35.3 ±15.6	36.1 ±11.3	0.8	39.1 ± 0.4	36.77 ±1.1	-2.4
Vitamin A (mg)	840	469.5 ±209.1	469.75 ±209.1	0.25	308.709 ±222.1	311.8 ±166.7	3.091
Dietary Fibre (g)	25	22.9 ±10.9	31.8 ±1.1	8.9	18.98 ±0.1	18.3 ±1.6	-0.68

Table LI illustrates that there was a shift in the amount of nutrients consumed by the Experimental and Control groups, before and after the dietary interventions. The selected subjects in Experimental group experienced the following changes: Energy increased from 1871.05±180Kcal to 1893.05±186KCal ; Carbohydrates reduced from 154.14±33.4g to 149.02±42.9g; Fat reduced from 18.71±11.2g to 11.02±13.6g; Calcium increased from 614.6±268.4mg to 633.1±204.4mg; Iron increased from 17.2048±5.22mg to 21.144±3.14mg; Folic Acid increased from 163.99±34.3µg to 168.31±30.3 µg; Vitamin C went from 35.3±15.6 mg to 36.1±11.3mg; Vitamin A went from 469.5±209.1mg to 469.754±209.1mg; and Dietary Fibre increased from 22.9±10.9g to 31.8±1.1g. There was an increase in Energy by 21.95 Kcal, Calcium by 18.5mg, Folic Acid by 4.32µg and Dietary

Fibre by 8.9 g. By conclusion, there was a meagre change in Vitamin C, A and Protein content of their diet. There was a fall in the consumption of Carbohydrates and Fat by 5.12g and 7.69g respectively. The change in the consumption pattern in the selected subjects could be due to the dietary interventions. The selected subjects were provided with comprehensive knowledge in nutrition, healthy diet pattern, adoption of physical activities and exercise. The change in the nutrient consumption indicated that the effect of nutrition education and dietary intervention on the nutritional status of the selected subjects.

In control group the change in nutrient consumption was from 1888.076±193 to 1891.024±193 in energy(Kcal) and 165.01±54.8 to 165.01±44.9 in carbohydrates(g). There was an increase in protein(g) from 36.57±26.02 to 40.33±26.9. There was only a meagre change in the consumption of fat (g) which was from 10.12±17.4 to 10.01±19.2. There was a decrease in calcium (mg) consumption from 701.5±233.1 to 655.1±204.4 and in Iron(mg) consumption from 23.678±9.16 to 23.132±0.14. There was a small change in Folic Acid(µg) consumption from 154.22±98.5 to 155.35±33.3. There was decrease in Vitamin C(mg) and Dietary Fibre (g)which was from 39.1±0.4 to 36.77±1.1 and 18.98±0.1 to 18.3±1.6 respectively. The change in Vitamin A(mg) was from 308.709±222.1 to 311.098±166.7. The change in intake of nutrients could be because of the lack of knowledge they had regarding the importance of proper nutrients in life as the selected subjects in control group was not a part of nutrition education programme.

Phase-V

4.5.Association studies to assess the effect of Nutrition Interventions on Nutritional Status of the selected subjects

Data collected for correlation of different aspects of Anthropometric Measurement, Biochemical Profile and Dietary Intake was assessed using Pearson Chi-square for categorical values and Pearson Correlation method for continuous values in SPSS.

4.5.1.Association between type of family and socio-economic status

Table LII represents the results for association study between Type of Family and Socio-Economic status of the selected subjects.

Table LII. Association between type of family and socio economic status

Parameter	$\chi 2$	p-value
Type of family and Socio economic status	7.515	0.002*

*Significant at 0.05 level

Table LII shows that there is a positive correlation between Type of Family and Socio-Economic status as the p-value is 0.002 which is < 0.05. The Pearson Chi-square coefficient was 7.515.

There is a clear correlation between socioeconomic status (SES) and the type of family structure. Socioeconomic status is generally measured by combining factors like income, education, and occupational prestige. Lower SES families are more likely to experience challenges such as poverty, unemployment, and limited access to resources, which can lead to different family dynamics and outcomes compared to higher SES families. For example, young adults from lower SES families are more likely to attend poorly resourced schools, have less access to other activities, and receive less support from the family and society stated by American Psychological Association (2018). In the current study there was an association between types of family and socio-economic status.

4.5.2.Association between occupation and socio-economic status

Table LIII represents the results for relation between Occupation and Socio-economic status.

Table LIII. Association between occupation and socio economic status

Parameter	$\chi 2$	p-value
Occupation and Socio-Economic status	2.770	0.047*

*Significant at 0.05 level

The Table LIII depicted that there was a positive correlation between Occupation and Socio-Economic Status. The p value is 0.047 which is less than 0.05. The Pearson Chi-square coefficient is 2.770.

Research shows that occupation is a reliable indicator of SES, although it is not always interchangeable with income or education. Each metric provides distinct insights into an individual's socioeconomic standing. For instance, education is linked to childhood social environments and future learning capabilities, whereas income represents immediate economic resources. On the other hand, occupation captures the broader context of work conditions and professional networks (Festin *et al.,* 2017). In the current study there was an association between occupation and socio-economic status.

4.5.3.Association between area of residence and type of transport

The Table LIV represents the results for the relationship between Area of Residence and Type of Transport.

Table LIV. Association between area of residence and type of transport

Parameter	$\chi 2$	p-value
Area of Residence and Type of Transport	1.973	0.373

Table LIV presents that the p-value for Area of residence and Type of Transport was 0.373 which is a more than 0.05. Therefore, the value is no significant association between Area of residence and Type of Transport.

Many studies suggest a relationship between area of residence and transportation choices, some research indicates that this association may not be as pronounced as previously thought. For instance, a study conducted in various urban and rural settings found that individual preferences, socioeconomic status, and lifestyle choices often overshadow the influence of residential area on transport mode selection (Rajabi *et al.,* 2024).

4.5.4.Association between BMI and Nutrient intake of the selected Over-weight subjects in Experimental Group

The Table LV presents the association between BMI and Nutrient Intake of Over-weight selected subjects in Experimental Group using Pearson Correlation method.

Table LV. Association between BMI and Nutrient intake of Over-weight subjects in Experimental Group

Nutrients	BMI			
	r(Pre)	p-value(Pre)	r(Post)	p value(Post)
Energy	0.106*	0.015	0.111*	0.010
Carbohydrate	0.065	0.148	0.065	0.148
Protein	0.009	0.837	0.0021	0.957
Fat	-0.033	0.457	-0.0321	0.457
Calcium	-0.031	0.488	-0.031	0.489
Iron	-0.142**	0.001	-0.143**	0.001
Folic Acid	-0.108*	0.015	-0.113*	0.015
Vitamin C	-0.035	0.435	-0.035	0.435
Vitamin A	0.068	0.127	0.078	0.136
Dietary Fibre	-0.006	0.898	-0.010	0.898

*Significant at 0.05 level, **Significant at 0.01 level

The results of Pearson's correlation shows that there was a positive correlation between energy and BMI (p=0.015, r=0.106) before nutrition intervention. The p value for the same was changed to 0.010 but correlation coefficient, r, changed to 0.111 after nutrition intervention. There was a high negative correlation at p=0.001 and r= -0.142 between BMI and Iron before nutrition intervention and the value remained the same but r= -0.143 after nutrition intervention. There was a high negative correlation between Folic Acid and BMI at p=0.015 and r= -0.108 before nutrition intervention and the p value remained the same but r= -0.113 after nutrition intervention.

There is a well-established positive correlation between body mass index (BMI) and energy intake in overweight individuals, which appears to be largely driven by the consumption of energy-dense foods. Studies have consistently shown that higher energy consumption, particularly from foods with a high energy density, is associated with increased BMI in overweight populations. For instance, a large study involving 1,312 overweight subjects found a direct positive relationship between energy intake and BMI in both males and females (Arango-Angarita *et al.,* 2018). In the present study high consumption of energy dese (fried foods) can be a factor for the association between BMI and Energy.

Obesity significantly impacts iron homeostasis, leading to disturbances that can result in iron deficiency despite adequate dietary intake. Studies have shown that overweight and obese individuals often exhibit lower serum iron levels and higher hepcidin concentrations, a hormone that regulates iron metabolism. The chronic low-grade inflammation associated with obesity is believed to elevate hepcidin levels, which in turn reduces iron absorption from the intestine and sequesters iron in macrophages, limiting its availability for erythropoiesis (Alshwaiyat *et al.,* 2021). The same trend was seen in the selected subjects in the experimental group in the present study.

Research has consistently shown a negative association between dietary folate intake and body mass index (BMI) in overweight individuals. Studies indicate that overweight and obese subjects often have significantly lower folate intake compared to their normal-weight counterparts; for instance, one study found that overweight individuals had 12 per cent lower folate intake, independent of overall diet quality. Additionally, obese women exhibited lower dietary folate consumption, with folate intake inversely related to both BMI and body fat percentage (Köse *et al.,* 2019). The same trend was seen in the present study.

4.5.5.Association between BMI and Nutrient intake of selected Over-weight subjects in Control group

Table LVI depicts the association between BMI and Nutrient Intake of selected subjects who are Over-weight in Control group.

Table LVI. Association between BMI and Nutrient intake of Over-weight subjects in Control Group

Nutrients	BMI			
	r(Pre)	p-value (Pre)	r (Post)	p value (Post)
Energy	0.110*	0.015	0.111*	0.015
Carbohydrate	0.067	0.148	0.067	0.148
Protein	0.003	0.829	0.002	0.829
Fat	-0.033	0.458	-0.033	0.458
Calcium	-0.031	0.488	-0.030	0.488
Iron	-0.142**	0.002	-0.144**	0.002
Folic Acid	-0.108*	0.015	-0.110*	0.015
Vitamin C	-0.023	0.426	-0.033	0.424
Vitamin A	0.068	0.127	0.068	0.127
Dietary Fibre	-0.005	0.897	-0.006	0.897

*Significant at 0.05 level, **Significant at 0.01level

The result of correlation between BMI and Nutrient intake for over-weight subjects in control group exhibits that there was a positive correlation between BMI and Energy where p=0.015 and r=-0.110 before intervention and it changed to p=0.015 and r=0.111.There was high negative correlation at p=0.002 and r= -0.142 between Iron and BMI before intervention and it changed to r= -0.144 and p value remained the same. There was a high negative correlation between Folic acid and BMI with p value as 0.015 and r value as -0.108 before intervention and it moved to r= -0.110 and p value remained as 0.015.

Control groups in weight loss interventions can exhibit weight changes even without specific interventions, highlighting the complexity of studying weight management in different populations (Zhu *et al.,* 2020). The same trend was seen in the present study.

4.5.6.Association between BMI and Nutrient intake of selected Under-weight subjects in Experimental Group

Table LVII depicts the relation between BMI and Nutrient intake of Under-weight selected subjects in Experimental group.

Table LVII. Association between BMI and Nutrient intake of Under-weight subjects Experimental Group

Nutrients	BMI			
	r(Pre)	p-value(Pre)	r (Post)	p value(Post)
Energy	0.109*	0.015	0.116*	0.015
Carbohydrate	0.034	0.198	0.070	0.149
Protein	0.003	0.987	0.009	0.845
Fat	-0.011	0.467	-0.031	0.453
Calcium	-0.027	0.488	-0.031	0.488
Iron	0.146**	0.001	0.153**	0.001
Folic Acid	0.108*	0.015	0.121*	0.013
Vitamin C	-0.089	0.435	-0.035	0.435
Vitamin A	0.065	0.127	0.070	0.127
Dietary Fibre	-0.003	0.922	-0.006	0.898

*Significant at 0.05 level, **Significant at 0.01 level

The results in Table LVII depicts that there was a correlation between BMI and Energy in Underweight selected subjects in Experimental group. The p value and r value before nutrition intervention is 0.015 and 0.109 respectively to p-value and r value to 0.015 and 0.116 respectively after intervention. There was high positive correlation for BMI and Iron with p =0.001 and r=0.146 before nutrition intervention to p=0.001 and r=0.153 after nutrition intervention. There was high positive correlation between Folic acid and BMI where p=0.015 and r=0.108 to p=0.013 and r=0.121 after nutrition intervention.

Research indicates that underweight individuals often exhibit lower energy intake and expenditure compared to their normal-weight counterparts. Studies have shown that healthy underweight individuals consume significantly less food—up to 12% less—than those with normal body mass index (BMI). This reduced intake is often accompanied by a lower overall activity level, with underweight individuals being approximately 23 per cent less active than their normal-weight peers. Despite having a higher resting metabolic rate, which includes elevated resting energy expenditure and thyroid activity, underweight individuals typically struggle with low appetite, nutrient malabsorption, and various factors such as genetics, illness, or eating disorders that contribute to their energy deficit (Hall *et al.,* 2022). Low BMI in the selected subjects can be a contributing factor for low energy in the selected under-weight subjects in the experimental group in the present study.

A study conducted in Bangladesh found that women with overweight/obesity had a lower likelihood of being anaemic compared to underweight women (Kamruzzaman, 2021). Folic acid deficiency is associated with various health issues, including anaemia, birth irregularities, and other complications. Folate is crucial for DNA production, red blood cell formation, and overall health (Mlodzik-Czyzewska *et al.,* 2020). This same trend was seen in the present study.

Underweight and anaemia are closely related, with studies showing a significant association between underweight status and an increased risk of anaemia among women. Research indicated that underweight women are more likely to experience iron deficiency, leading to iron-deficient anaemia. The prevalence of anaemia among underweight women is notably higher compared to normal or overweight women. Additionally, low serum ferritin levels and elevated serum transferrin receptor levels are indicators of iron depletion and iron-deficient erythropoiesis, which are more common in underweight individuals. The occurrence of iron-deficient anaemia is particularly high among underweight women, highlighting the impact of nutritional status on anaemia risk (Kamruzzaman, 2021) and (Sumarmi *et al.,* 2016). The same trend was seen in the present study where there was an association between BMI and Iron intake in diet.

4.5.7.Association between BMI and Nutrient intake of selected Under-weight subjects in Control Group

Table LVIII depicts the relationship between BMI and Nutrient intake of the selected Under-weight subjects in Control group.

Table LVIII. Association between BMI and Nutrient intake of Under-weight subjects in Control group

Nutrients	BMI			
	r(Pre)	p-value(Pre)	r (Post)	p value(Post)
Energy	0.110*	0.015	0.110*	0.015
Carbohydrate	0.044	0.197	0.044	0.197
Protein	0.002	0.988	0.002	0.987
Fat	-0.011	0.467	-0.014	0.467
Calcium	-0.029	0.487	-0.029	0.487
Iron	0.138**	0.001	0.138**	0.001
Folic Acid	0.098*	0.017	0.090*	0.018
Vitamin C	-0.089	0.439	-0.082	0.440
Vitamin A	0.056	0.123	0.056	0.123
Dietary Fibre	-0.003	0.922	-0.003	0.923

*Significant at 0.05level, **Significant at 0.01level

Table LVIII presents correlation between BMI and Nutrient intake of Underweight selected subjects in Control group where there exists a correlation between BMI and Energy where p=0.015 and r=0.110 before nutrition intervention and the p and r value remained same after intervention too. The p and r value for Iron and BMI before intervention was highly significant at 0.001 and 0.138 respectively. The p and r value remained same after intervention between BMI and Iron. There was significance at p=0.017 and r= 0.098 before nutrition intervention for BMI and Folic acid to p=0.018 and r=0.090 after nutrition intervention.

A systematic review indicated that nutrition interventions, particularly those combining dietary modifications with exercise, effectively reduced BMI in women with overweight or obesity compared to control groups. However, other studies have revealed that control groups, which did not receive any nutritional support, often exhibited no significant changes in BMI, emphasizing the importance of active participation in structured programs. Additionally, research has found no significant correlation between nutrition knowledge and BMI, suggesting that providing information alone may not lead to meaningful weight changes. Overall, while targeted nutrition interventions can positively influence BMI, the effectiveness largely depends on the specific strategies employed and

the level of engagement from participants, underscoring the need for tailored approaches to achieve desired outcomes in underweight and overweight women (Lin *et al.,* 2023).The same trend was observed in the present research study.

4.5.8.Association between WHR and Nutrient intake of selected Over-weight subjects in Experimental group

The Table LIX presents the association between WHR and Nutrient intake for Over-weight selected subjects in Experimental group

Table LIX. Association between WHR and Nutrient intake of Over-weight subjects in Experimental Group

Nutrients	WHR			
	r(Pre)	p-value(Pre)	r (Post)	p value(Post)
Energy	-0.138	0.324	-0.140	0.324
Carbohydrate	0.355**	0.001	0.410**	0.001
Protein	0.078	0.580	0.078	0.581
Fat	0.009	0.950	0.009	0.950
Calcium	-0.153	0.274	-0.154	0.274
Iron	0.009	0.949	0.009	0.949
Folic Acid	0.245	0.077	0.249	0.070
Vitamin C	0.150	0.284	0.150	0.282
Vitamin A	0.252	0.068	0.263	0.067
Dietary Fibre	0.147	0.294	0.147	0.294

**Significant at 0.01 level

The results for correlation between WHR and Nutrient intake of Experimental group is depicted in Table LIX where there was a high correlation between WHR and Carbohydrates. The p value was 0.001 and r value is 0.355 before nutrition intervention and after nutrition intervention it had altered to p=0.001 and r =0.410.

There is limited direct research specifically examining the correlation between waist-to-hip ratio (WHR) and carbohydrate consumption in overweight women; however, relevant studies provide valuable insights. One study focuses on the Carbohydrate Quality Index (CQI) and its association with various anthropometric measures, including WHR, in overweight and obese individuals. Although it emphasizes the quality rather than the

quantity of carbohydrates, the findings suggest that carbohydrate intake patterns are linked to anthropometric markers like WHR (Khosravinia*, et al.,* 2022). In the present study it can be attributed to the factor that high consumption of junk food which contains poor quality carbohydrates, in selected over weight subjects which had shown an association between WHR and carbohydrates.

4.5.9.Association between WHR and Nutrient intake of selected Over-weight subjects in Control Group

The Table LX depicts the Pearson Correlation between WHR and Nutrient Intake of the selected Over- weight selected subjects in Control Group

Table LX. Association between WHR and Nutrient intake of Over-weight subjects in Control group

Nutrients	WHR			
	r(Pre)	p-value(Pre)	r (Post)	p value(Post)
Energy	-0.148	0.336	-0.149	0.333
Carbohydrate	0.246**	0.009	0.246**	0.009
Protein	0.066	0.588	0.073	0.591
Fat	0.010	0.950	0.010	0.952
Calcium	-0.150	0.279	-0.165	0.261
Iron	0.009	0.963	0.009	0.963
Folic Acid	0.245	0.077	0.246	0.077
Vitamin C	0.145	0.284	0.169	0.263
Vitamin A	0.245	0.068	0.245	0.068
Dietary Fibre	0.147	0.296	0.149	0.296

**Significant at 0.01 level

The results for correlation between WHR and Nutrient Intake in Control group with Over-weight selected subjects shows a high correlation at p=0.009 and r=0.246 before nutrition intervention and the p and r value remains same after nutrition intervention.

4.5.10.Association between WHR and Nutrient intake of selected Under-weight subjects in Experimental Group

The Table LXI depicts the association between WHR and Nutrient Intake in Under-weight selected subjects belonging to Experimental Group

Table LXI. Association between WHR and Nutrient intake of Under-weight subjects in Experimental Group

Nutrients	WHR			
	r(Pre)	p-value(Pre)	r(Post)	p value(Post)
Energy	0.384**	0.007	0.385**	0.007
Carbohydrate	-0.116	0.447	-0.116	0.447
Protein	0.062	0.668	0.063	0.668
Fat	0.358*	0.016	0.358*	0.014
Calcium	0.096	0.530	0.096	0.530
Iron	0.221	0.145	0.231	0.140
Folic Acid	0.141	0.354	0.141	0.354
Vitamin C	-0.233	0.124	-0.234	0.124
Vitamin A	0.090	0.556	0.090	0.556
Dietary Fibre	0.095	0.536	0.095	0.536

*Significant at 0.05 level, **Significant at 0.01 level

From table LXI it was evident to note that there was a high positive correlation between the WHR and Energy where the p value is 0.007 and r value is 0.384 before nutrition intervention and the p value remains the same after nutrition intervention and r value had an alteration to 0.385 after nutrition intervention. There was a significant correlation between fat intake and WHR where the p value was 0.016 and r value was 0.358 before nutrition intervention and the value moved to p=0.014 and r=0.358 after nutrition intervention.

The correlation between Waist-to-Hip Ratio (WHR) and energy consumption in women is not directly established in any research study. However, the relationship between WHR and various factors related to body composition, such as Percentage Body Fat (PBF), Waist Circumference (WC), and abdominal muscle strength, has been studied. A study found a positive correlation between WHR and PBF, as well as WHR and WC in females (Arif *et al.,* 2022). The association which was seen in the present study can be attributed to the fact that there is a relationship between WHR and PBF.

4.5.11.Association between WHR and Nutrient intake of selected Under-weight subjects in Control Group

Table LXII portrays the results of association between WHR and Nutrient intake of selected Under-weight subjects in Control group.

Table LXII. Association between WHR and Nutrient intake of Under-weight subjects in Control group

Nutrients	WHR			
	r(Pre)	p-value (Pre)	r(Post)	p-value (Post)
Energy	0.386**	0.009	0.386**	0.009
Carbohydrate	-0.114	0.447	-0.115	0.447
Protein	0.070	0.667	0.064	0.668
Fat	0.366*	0.015	0.366*	0.015
Calcium	0.096	0.530	0.094	0.530
Iron	0.235	0.136	0.236	0.136
Folic Acid	0.143	0.354	0.143	0.355
Vitamin C	-0.233	0.124	-0.234	0.124
Vitamin A	0.098	0.556	0.090	0.553
Dietary Fibre	0.095	0.539	0.095	0.539

*Significant at 0.05 level, **Significant at 0.01 level

The results showed a high significance at p=0.009 and r=0.386 for the correlation between WHR and Energy before nutrition intervention and the p and r values remained same after nutrition intervention. There was a positive correlation between fat intake and WHR in underweight selected subjects where p= 0.015 and r=0.366 before nutrition intervention and the values remained same after nutrition intervention.

In a study comparing waist-related anthropometric measures between experimental group and a control group, it was found that the impact of nutrition intervention on waist circumference in the experimental group was higher than in the control group. The mean waist-to-hip ratio (WHR) was also reported to be higher in the study group compared to the

control group (Kaur *et al.,* 2015).In the current study there was a slight change in WHR in experimental group than in control group after nutrition intervention.

4.5.12.Association between Biochemical Profile and Nutrient Intake of selected subjects in Experimental Group before Nutrition Interventions

The relationship between Biochemical Profile and nutrient intake was examined for Experimental Group. The statistical tool of Pearson's correlation was used as it is a continuous value. Table LXIII depicts the Pearson's correlation value and p –value for correlation between blood parameter and nutrient intake of selected subjects in Experimental Group before intervention.

Table LXIII. Association between Biochemical Profile and Nutrient intake of selected subjects in Experimental Group before nutrition intervention

Nutrients	Serum Iron		Serum Folic Acid		Serum Calcium	
	r	p -value	r value	p-value	r	p-value
Energy	-0.179	0.213	0.071	0.601	-0.086	0.576
Carbohydrate	0.110	0.445	0.076	0.576	-0.168	0.269
Protein	-0.067	0.643	-0.014	0.920	0.097	0.526
Fat	0.210	0.143	0.039	0.776	-0.033	0.829
Calcium	0.036	0.801	-0.048	0.722	0.009	0.231
Iron	0.009	0.348	-0.105	0.437	-0.038	0.805
Folic Acid	-0.214	0.136	0.007	0.078	0.063	0.681
Vitamin C	-0.096	0.505	0.130	0.333	-0.14	0.928
Vitamin A	0.156	0.280	-0.049	0.718	0.341*	0.022
Dietary Fibre	-0.332*	0.018	0.098	0.467	0.277	0.065

*Significant at 0.05 level

The correlation was between Serum Iron, Serum Folic Acid and Serum calcium with Nutrient Intake for 250 selected subjects who are in Experimental group. The correlation of Serum Iron and Nutrient Intake presents that, there was weak negative correlation between serum iron and energy. There was a negative weak correlation between Serum Iron with Folic acid, protein and Vitamin C. There was a high negative correlation between Serum Iron and Dietary Fibre at p=0.018 and r= -0.332. Serum Folic Acid and Nutrient Intake results shows that there was no significant correlation with any of the nutrients .Serum Calcium and Nutrient Intake shows a positive correlation between Vitamin A and Serum Calcium at p=0.002 and r= 0.341.

The relationship between dietary fibre and iron is complex. While some studies suggest that the fibre content of fruits and vegetables can influence iron stores in women (Péneau *et al.,* 2018). Dietary fiber can inhibit iron absorption, particularly nonheme iron, although the extent of this effect varies by fiber type. A study by Piskin *et al.,* (2022) found that meals with high fiber content resulted in lower iron absorption (2.96%) compared to low-fiber meals (6.07%), indicating that while fiber can impair iron absorption. The same trend ws seen in the present study.

A study highlighted that higher serum calcium levels were positively associated with metabolic syndrome and its components, suggesting that vitamin A's role in metabolic processes could relate to calcium regulation. Additionally, vitamin A is involved in the synthesis of proteins that are crucial for bone health, potentially affecting calcium absorption and utilization (Borgan *et al.,* 2022). The same trend was observed in the present study.

4.5.13.Association between Biochemical Profile and Nutrient intake of the selected subjects in Experimental Group after Nutrition Intervention

The Table LXIV depicts the association between Biochemical Profile and Nutrient Intake for Experimental Group after Nutrition Intervention.

Table LXIV. Association between Biochemical Profile and Nutrient intake for Experimental Group after nutrition intervention

Nutrients	Serum Iron		Serum Folic Acid		Serum Calcium	
	r	p value	r	p-value	r	p-value
Energy	-0.289	0.211	0.077	0.601	-0.160	0.576
Carbohydrate	0.113	0.445	0.076	0.576	-0.168	0.269
Protein	-0.172	0.639	-0.014	0.920	0.101	0.521
Fat	0.210	0.143	0.149	0.776	-0.033	0.829
Calcium	0.038	0.800	-0.048	0.722	0.009	0.230
Iron	0.009	0.348	-0.110	0.444	-0.198	0.800
Folic Acid	-0.214	0.136	0.109	0.076	0.063	0.681
Vitamin C	-0.097	0.505	0.130	0.333	-0.14	0.928
Vitamin A	0.154	0.280	-0.053	0.717	0.431*	0.019
Dietary Fibre	-0.350*	0.018	0.098	0.467	0.276	0.065

*Significant at 0.05 level

Table LXIV depicts a Pearson Correlation statistical Analysis to predict any association between blood parameters and nutrient intake of Experimental group after intervention. There was a significant negative association between dietary fibre and Serum Iron at p=0.018 and r= -0.350. There was a positive correlation between Vitamin A and Serum Calcium at p=0.019 and r=0.431. There was change in r and p values after nutrition intervention in the experimental group.

Research studies have shown a positive association between the consumption of fiber-poor fruits, vegetables, and juices (FVJ) and iron status. Specifically, in women, higher intake of fiber-poor FVJ was linked to increased serum ferritin concentrations. Additionally, in the general sample, haemoglobin levels were positively associated with the consumption of fruits, vitamin C-rich FVJ, FVJ ascorbic acid, and fiber-poor FVJ categories (Péneau *et al.,* 2018).

Vitamin A can have both positive and negative impacts on bone health. While adequate vitamin A intake is necessary for maintaining bone health, high concentrations of vitamin A could reduce the function of vitamin D, which is crucial for calcium absorption and maintaining bone homeostasis. Studies have shown a direct relationship between vitamin A intake and bone health, with protective effects reported in several cohorts and studies (Yee *et al.,* 2021). Findings of the present study reflected these studies.

4.5.14.Association between Biochemical profile and Nutrient Intake of selected subjects in Control Group before Nutrition Intervention

The association between Biochemical profile and Nutrient Intake for Control Group before Intervention was carried out using Pearson's Correlation. The results were enlisted according to the r value and the p value. The results of the correlation between blood parameters and nutrient intake is depicted in Table LXV.

Table LXV. Association between Biochemical Profile and Nutrient intake of selected subjects in Control group before nutrition intervention

Nutrients	Serum Iron		Serum Folic Acid		Serum Calcium	
	r	p value	r	p-value	r	p-value
Energy	-0.167	0.398	0.056	0.709	-0.098	0.576
Carbohydrate	0.116	0.445	0.089	0.688	-0.168	0.297
Protein	-0.098	0.789	-0.014	0.931	0.098	0.531
Fat	0.211	0.234	0.057	0.776	-0.044	0.889
Calcium	0.036	0.908	-0.056	0.722	0.011	0.313
Iron	0.009	0.348	-0.105	0.437	-0.038	0.805
Folic Acid	-0.209	0.139	0.007	0.078	0.090	0.666
Vitamin C	-0.009	0.567	0.130	0.378	-0.78	0.954
Vitamin A	0.156	0.299	-0.078	0.933	0.321*	0.022
Dietary Fibre	-0.216*	0.019	0.098	0.567	0.267	0.090

*Significant at 0.05 level

The result in Table LXV depicts that there is a negative correlation between Serum Iron and Dietary fibre at p=0.019 and r= -0.216 before nutrition intervention. The Serum Calcium and Vitamin A showed a correlation at p=0.022 and r=0.321 before nutrition intervention in Control Group.

4.5.15.Association between Biochemical Profile and Nutrient intake of the selected subjects in Control Group after Nutrition Intervention

The Table LXVI depicts the association between Biochemical Profile and Nutrient Intake for Control Group after Nutrition Intervention

Table LXVI. Association between Biochemical Profile and Nutrient intake for Control group after nutrition intervention

Nutrients	Serum Iron		Serum Folic Acid		Serum Calcium	
	r	p value	r	p-value	r	p-value
Energy	-0.167	0.398	0.056	0.709	-0.098	0.576
Carbohydrate	0.116	0.445	0.089	0.688	-0.168	0.297
Protein	-0.098	0.789	-0.014	0.931	0.098	0.531
Fat	0.211	0.234	0.057	0.776	-0.044	0.889
Calcium	0.036	0.908	-0.056	0.722	0.011	0.313
Iron	0.009	0.348	-0.105	0.437	-0.038	0.805
Folic Acid	-0.209	0.139	0.007	0.078	0.090	0.666
Vitamin C	-0.009	0.567	0.130	0.378	-0.78	0.954
Vitamin A	0.156	0.299	-0.078	0.933	0.321*	0.018
Dietary Fibre	-0.216*	0.019	0.098	0.567	0.267	0.090

*Significant at 0.05 level

The results depicted that the p value and r value for the correlation for Serum Iron and Dietary fibre remained same after the nutrition intervention. (p=0.019 and r= -0.216). The correlation of Serum Calcium and Vitamin A changed to p=0.018 and r value remained the same at 0.321 after nutrition intervention.