3. METHODOLOGY

The methodology pertaining to the study “EFFECT OF OPTIMIZED BREAKFAST BAR ON NUTRITIONAL AND ACADEMIC PERFORMANCE OF THE SELECTED ADOLESCENTS” was discussed under following phases.

3.1 Phase I: Optimization of breakfast bars using Response Surface Methodology (RSM)

3.1.1 Selection of flakes

3.1.2 Physical parameters of the selected flakes
   3.1.2.1. Thousand-flakes weight (kg/hl)
   3.1.2.2. Bulk density (g/cm$^3$)
   3.1.2.3. Size and Thickness (mm)
   3.1.2.4. Sogginess (Disappearance of crispiness) (mins)
   3.1.2.5. Water absorption capacity (ml)
   3.1.2.6. Oil absorption capacity (ml)

3.1.3. Optimization of breakfast bars using Response Surface Methodology (RSM)
   3.1.3.1. Experimental design for the process of optimization

3.1.3.2. Development of breakfast bar
   3.1.3.2.1. Procedure for developing breakfast bars
      a. Ingredients
      b. Procedure

3.1.4. Physical parameters of the developed breakfast bars
   3.1.4.1. Diameter and width
   3.1.4.2. Weight of the bar
   3.1.4.3 Cooking time

3.1.5. Analysis of the nutrients presents in the developed breakfast bars

3.1.6. Organoleptic evaluation of the developed breakfast bars
3.2. Phase II: Assessment of socio-economic, dietary pattern, nutritional status and academic performance of the selected subjects

3.2.1. Selection of area and subjects

3.2.2. Preparation of interview schedule
   3.2.2.1. Assessment of socioeconomic and general information of selected subjects
   3.2.2.2. Assessment of dietary pattern of the selected subjects
   3.2.2.3. Assessment of nutritional status of the selected subjects
   3.2.2.4. Assessment of academic performance of the selected subjects

3.3. Phase III: Assessment of supplementary impact of breakfast bar on

3.3.1. Mean nutrient intake of the selected subjects
3.3.2. Anthropometric measurements of the selected subjects
3.3.3. Academic Performance of the selected subjects

3.4. Phase IV: Study of impact of nutrition education among the selected subjects

3.4.1. Preparation of teaching aids
3.4.2. Assessment of final nutritional knowledge

3.5. Statistical analysis of the data
RESEARCH DESIGN

ADOLESCENTS (N – 500)

Demographic Assessment (N-500)
Nutritional assessment (N-500)
Dietary assessment (N-500)
Life style pattern assessment (N-500)
Academic performance assessment (N-500)

Sub sample (N – 150)

Breakfast Consumer (N – 50)
Breakfast Skippers (N – 100)

Control group (N-50) consuming regular homemade breakfast
Experimental group I (N=50) breakfast skipper not subjected to any intervention
Experimental group II (N=50) supplemented with breakfast bar (240g) for three months

Nutritional knowledge assessment
Optimization of breakfast bar with twenty variations

Variation 5 was selected for supplementation. (Mixture flakes -24g, groundnut -11g and chocolate chip - 8g)

After evaluation subjects who secured low scores are selected for nutrition education

Analysis of Initial and Final values of Nutrient intake
Nutritional Status
Academic performance

Pre and Post analysis of nutrition knowledge

Statistical analysis
3.1 Phase I: Optimization of breakfast bars using Response Surface Methodology (RSM)

3.1.1. Selection of flakes

Breakfast cereals represent a healthy breakfast choice. They are made from grain; they are typically high in carbohydrates, low in fat, and often a good source of fibre. Breakfast cereals are a “nutrient dense” food, i.e. while supplying only a modest amount of energy (calories) they make a significant contribution to intakes of essential nutrients: carbohydrates, proteins, fats, vitamins and minerals.

Flakes are defined as a flat thin piece or layer; a chip. There are different types of flakes are available in the market; among that four types of flakes namely Corn, oats, wheat and rice flakes were chosen for this study. **Corn flakes** are a kind of ready to eat breakfast cereals characterized by the thin shape and crispness. It is eaten along with or with out added sugar. 100 gram of cornflakes contains 4 grams of protein, 3.5 grams of dietary fiber, 24g of total carbohydrates, 418 calories, 200mg of sodium, 25mg of potassium and some other rich nutrients are thiamin, riboflavin, niacin, vitamin B6, folic acid and vitamin B12 ([www.thefatlossauthority.com](http://www.thefatlossauthority.com)).

**Wheat flakes** are partially boiled cracked wheat crushed between rollers then dried, lightly toasted and used in muesli and as a breakfast cereal. Hundred grams of wheat flakes contains 90.5k.cal, 3g of protein, 0.5g of fat, 24g of carbohydrate and 180mg of sodium. **Rice** grain steamed or softened by partial cooking and flattened through rollers, may be cooked or eaten uncooked are called rice flakes ([www.food-dictionary.com](http://www.food-dictionary.com)). Hundred grams of rice flakes contains 100k.cal, 22g of carbohydrate, 7g of protein and 210 mg of sodium. **Oat flakes** are produced by heating either pinhead oatmeal or whole oats with steam as they are passed through rollers to flatten them. Hundred grams of oat flakes contains 138 kilo calories, 2.1 g of fat, 25.5g of carbohydrate and 4.5 g of protein. All the four selected flakes are analyzed for their physical parameters.
3.1.2. Physical parameters of the selected flakes

The following parameters were used to assess the physical characteristics of the flakes chosen for the development of the breakfast bars. The parameters are as follows

3.1.2.1. Thousand-flakes weight (kg/hl)

The thousand – flakes weight was determined on the raw flakes by weighing 1000 flakes and multiplying their weight by 10. The thousand –flakes weight was determined using the method of Cruzy et.al., (1996).

3.1.2.2. Bulk density (g/cm$^3$)

The bulk density of the (Rahman, 1995) flakes was determined by replacing the flakes into a 500 ml graduated cylinder. The volume and weight of the flakes were recorded to determine the bulk density as the weight of flakes per volume occupied by flakes.

3.1.2.3. Size and Thickness (mm)

The flakes size and thickness were determined on 30 flakes per treatment using vernier calipers.

3.1.2.4. Sogginess (Disappearance of crispiness) (mins)

The sogginess was determined subjectively by placing 20g sample in cold milk (10º C) and chewing a soaked flakes at 1 minute intervals until crispiness disappeared. The time (minutes) for crispiness to disappear was recorded as sogginess. The sogginess was determined by the method of Cruzy et.al (1996).

3.1.2.5. Water absorption capacity (ml)

The water absorption capacity of the flakes was determined by the slightly modified method of Sathe et al., (1982). 10ml of water was added to 1gm each sample in a beaker, the suspension was stirred using magnetic stirred for 5 min at 1000 rpm on Gallankamp magnetic stirrer hot plate. The suspension was transferred into centrifuge tube and centrifuged at 3500rpm for 30mins; the volume of the supernatant obtained was measured. The density of the water was assumed to be 1gm/ml. The water absorbed by the flakes and the volume of the supernatant obtained after centrifuging was noted.

\[
\text{Water absorption (ml)} = \frac{\text{Weight of sediment}}{\text{Weight of sample}}
\]
3.1.2.6. Oil absorption capacity (ml)

The oil absorption was determined using the method of Lin et al., (1986). The sample (500mg) was added to about 10 ml of oil, mixed thoroughly and agitated for 1 hour. Then the sample was centrifuged at 2000 rpm for 30 minutes. The supernatant was discarded and sediment weighed.

\[
\text{Oil absorption (ml)} = \frac{\text{Weight of sediment}}{\text{Weight of sample}}
\]

3.1.3. Optimization of breakfast bar using Response Surface Methodology (RSM)

3.1.3.1. Experimental design for the process of optimization

Response surface methodology was applied to the experimental data using a commercial statistical package (Design expert, Trail version 7.0, State Ease Inc., Minneapolis, IN statistical software) for the generation of response surface plot and optimization of process variables. The experiments were conducted according to Central Composite Rotatable Design (CCRD) (Khuri, al and Cornell. JA, 1997). A $3^5$ factorial experiment was used to study the effects of mixture flakes ($X_1$), groundnut ($X_2$) and chocolate chips ($X_3$) on the response variables such as over all acceptability ($Y_1$), weight ($Y_2$), diameter ($Y_3$), width ($Y_4$) calorie ($Y_5$), protein ($Y_6$), fat ($Y_7$), carbohydrate ($Y_8$) for the development of breakfast bars.

Table-2

<table>
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<th>Variables</th>
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<td>Ground Nut</td>
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<tr>
<td>Chocolate Chips</td>
<td>$X_3$</td>
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Table- 3
Observed values of dependent variables for different runs of optimization experiments

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<th>Design point</th>
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<th>Coded</th>
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</tbody>
</table>

MF = Mixture Flakes, GN = Ground Nut, CC = chocolate chips

Each design point consists of the replicates. For the statistical analysis the numerical levels are standardized to -1, 0 and +1. The experiments were carried out in randomized order (Gacula and Singh, 1984). The relationship between standardized variables values is given as follows
The standard scores were fitted to a quadratic polynomial regression model for predicting individual Y responses by employing at least square technique (Wanasaundara and Shahidi, 1996). The second order polynomial equation was fitted to the experimental data of each dependent variable as given. The model proposed to each response of Y was

\[
Y = \beta_0 + \sum_{i=1}^{3} \beta_i X_i + \sum_{i=1}^{3} \beta_i^2 X_i^2 + \sum_{i<j=1}^{3} \beta_{ij} X_i X_j
\]

Where, \(\beta_0,\ beta_i,\ beta_j\) and \(\beta_{ij}\) → regression coefficient

\(X_i\) and \(X_j\) → independent variable

\(Y\) → dependent variable

The model permitted evaluation of quadratic terms of the independent variables on the dependent variable. The response surface and contour plot were generated for different interactions of any two independent variables, where holding the value of third variables as constant at central level. The optimization of the process was aimed at finding the optimum values of independent variables (Wanasaundara and Shahidi, 1996).
3.1.3.2. Procedure for developing breakfast bars

The breakfast bar development procedure reported by Fast and Caldwell (1990) was adopted for producing the breakfast bar. Apart from the four types of flakes (corn flakes, oat flakes, rice flakes and wheat flakes at the ratio of 1:1:1:1) other ingredients namely sugar, groundnut, chocolate chips, vanaspathi, butter, glycerin, essence, sodium bi carbonate and sesame are used for the same. All these are purchased from the local market of Salem and checked for its purity before used in the breakfast bar development. Following this method twenty different formulations of breakfast bar in triplicate varying cereal flakes, groundnut and chocolate chips concentration were developed.

a. Ingredients

1. Sugar
2. Mixture flakes (Corn/Oat/Rice/Wheat flakes at the ratio of 1:1:1:1)
3. Groundnut
4. Chocolate chips
5. Vanaspathi
6. Butter
7. Glycerin
8. Essence
9. Sodium bi carbonate
10. Sesame

b. Procedure

1. Combine all flakes, vanaspathi, sodium bi carbonate and ground nut in the bowl of a large mixer. Mix for 1 minute.
2. Add sugar syrup, butter, essence, glycerin and water.
3. Add chocolate chips and mix briefly (just until mixture is combined).
4. Sheet dough to 10 mm (0.4") and cut in to 7.5 × 3.75cm (3×1.1/2" pieces. Place on parchment lined pans so they are not touching one another.
5. Bake in oven at 204º C (400º F) for 5 minutes.
PLATE I

INGREDIENTS FOR BREAKFAST BARS

- Water
- Baking Soda
- Vanaspati
- Butter
- Sesame
- Glycerin
- Sugar
- Chocolate chips
- Mixture of flakes
- Groundnut
PLATE II
BREAKFAST BARS DEVELOPMENT

Step 1: Combine all flakes, vanaspathi, butter, sodium bi carbonate and ground nut and chocolate chips.

Step 2: Make sugar syrup
Step 3: Put all ingredients in a large mixer and grind the ingredients along with sugar until mixture is combined well.

Step 4: Breakfast bar dough
Variation 5 was selected for supplementation.
3.1.4. Physical parameters of the developed breakfast bars

The physical parameters of the 20 developed breakfast bar were analyzed by the following methods.

3.1.4.1. Diameter and width

The developed breakfast bars diameter and width was assessed by using the vernier caliper and recorded in cms.

3.1.4.2. Weight of the bar

Weight of the bar is measured by using a weighing balance and recorded in kilograms.

3.1.5. Analysis of the nutrients in the developed breakfast bars

The developed breakfast bars were analyzed for its nutrient composition by using the methods as follows (Annexure –II).

1. Energy (Kcal) - Calculation method
2. Protein (g) - Lowry’s method
3. Fat (g) - Soxhlet method
4. Total carbohydrate (g) - Anthrone method
5. Iron (mg) - NIN method

3.1.6. Organoleptic evaluation of formulated breakfast bars

An organoleptic quality was a combination of different senses of perception coming to play in choosing and eating a food. All the 20 developed breakfast bars were evaluated thrice for their acceptability by a panel of 10 judges selected at random from Department of Food Science, Periyar University, Salem. All the judges were asked to score the products for appearance, colour, flavour, texture, taste and over all acceptability using a 9 point hedonic scale. Score card with scores ranging from 9 to 1 where scores 9 and 1 represents like extremely and dislike extremely respectively was used for evaluating the developed products.
3.2. Phase II: Assessment of socio-economic, dietary pattern, nutritional status and academic performance of the selected subjects

3.2.1. Selection of area

The study was conducted in Salem district, Tamil Nadu State. Five hundred adolescents under the age group of 13-15 were selected from Glaze Brooke Matric Higher Secondary School, Salem, Government Higher Secondary School, Kannangkuruchi, Salem and Anderson Higher Secondary School, Salem. These subjects were selected on the basis of convenience sampling method. Among the selected subjects 336 were boys and 164 were girls. The study was approved by Institutional Ethical committee (IEC).

3.2.2. Formulation of interview schedule

Interview schedule (Annexure I) is the best method of acquiring information from the subjects as the data are reliable and changes of misinterpretation are minimum. So an interview schedule is formulated to elicit data’s regarding

3.2.2.1. Socioeconomic and general information of the selected subjects
3.2.2.2. Dietary pattern of the selected subjects
3.2.2.3. Assessment of nutritional status
3.2.2.4. Assessment of academic performance

3.2.2.1. Socioeconomic and general information of the adolescents

The socioeconomic profile such as age, sex, ethnic group, type of family, monthly income and educational level of the parents were collected using the questionnaires. Life style pattern such as smoking, drinking, dieting, soft drink consumption, physical activity, time spent for doing his/her activities at home were also elicited from the developed questionnaire.
3.2.2.2. Dietary pattern of the selected subjects

The purpose of the diet history is to obtain an account of a subject’s usual food intake. Structurally it takes the form of a description of meals consumed throughout the day (Bauer and Sokolik, 2002).

Dietary survey was conducted for all the selected subjects to gather the required information on snack food consumption pattern like biscuits, chocolate and ice cream, fast food consumption regarding pizza, noodles, burger, fried rice etc and breakfast skipping habits and reason for skipping the breakfast. Three day dietary recall method was used to measure the dietary intake of a sub sample of 150 subjects. Nutrient content of the food item was assessed making use of the food composition table given by ICMR (Gopalan et.al., 2004).

3.2.2.3 Assessment of nutritional status of the adolescents

3.2.2.3.1 Anthropometric measurements

Anthropometric parameters like height, weight, Body Mass Index (BMI) and body fat percentage were calculated for all the 500 subjects.

3.2.2.3.1.1. Height

Height is an important parameter of nutritional status, which provides information about body size that is critical for monitoring care and for establishing nutrient requirement (Ramakrishnan, 1999). The subjects were asked to stand erect against a wall with heels to gather and toe apart without shoes. A mark was made with a scale rested flat on the head. The heights of all the subjects were measured using a non-stretchable measuring tape.

3.2.2.3.1.2. Weight

Weight is the simplest measurement of nutritional status. The weighing machine used for measuring should be accurate and reliable (Hisch and Bachelor, 1999). Weighing balance was used to measure the body weight of all the selected subjects wearing light clothing, to the nearest 0.5kg.
3.2.2.3.1.3. Body Mass Index (BMI)

The weight for height ratio is a simple and widely accepted method which estimates total body mass rather than fat mass. It correlates very well with the amount of body fat. The most commonly used ratio is the Quetlet’s index of Body Mass Index. It is the most widely used critical tool for measurement of obesity. It was calculated as weight in kilograms divided by the square of height in meters as shown below.

\[ \text{BMI} = \frac{\text{Weight in Kgs}}{\text{Height in } \text{m}^2} \]

3.2.2.3.1.4. Body Fat Percentage

The body fat percentage was measured using the OMRON body fat monitor. OMRON Body fat Monitor measures the body fat percentage by the Bioelectrical Impedance (BI) method. To calculate the body fat percentage from the electric conductivity between both hands, the following five items namely 1) Electric resistance, 2) Height, 3) Weight, 4) Age and 5) Gender were taken and a formula were employed to obtain the results.
PLATE IV
OMRON BODY FAT MONITOR
3.2.2.4. Assessment of academic performance

Academic Performance Scale was used to find the subject’s academic performance over the past week (Annexure-III). The academic performance was assessed by using four types of scales namely Arithmetic, Concept and process, Writing and Reading scales. The arithmetic scale includes number sense, estimation and computation, algebra, geometry, measurements, statistical and probability, problem solving and reasoning and proofs and each heading comprises of 11 questions. Concept and processes scale contains unifying concepts of science, scientific inquiry, general science scale, life science, earth/space science and physical science and each heading having 11 questions. Writing scale includes composition/writing process, composition structure, basic grammar and usage, punctuation, capitalization, word recognition and vocabulary consist of 11 questions in each heading and reading scale contains of reading comprehension literal, reading comprehension-inferential /interpretive, reading comprehension-evaluation and literary response and analysis, each heading composed of 11 questions. The subjects were encouraged to answer the academic performance questionnaire.

3.3 Phase III: Assessment of supplementary impact of breakfast bar on nutrient intake, nutritional status and academic performance of selected subjects

Among the 500 school students surveyed, 50 breakfast consumers having regular homemade breakfast and 100 breakfast skippers not consuming breakfast for more than one month (Moore, Moore, & Murphy 2009) belonged to age group of 13-15 years are selected by convenience sampling method. Fifty breakfast consumers were taken as Control group (n=50) and 100 breakfast skippers are divided into two groups as below.

1. Experimental group – I: This group is not subjected to any intervention strategy.

2. Experimental group II: Supplemented with 240g of breakfast bars daily for the period of 90 days.

The effect of supplementation was studied by assessing the final nutrient intake, nutritional status and academic performance using the same procedure among the selected subjects.
3.4. Phase IV: Study of impact of nutrition education among the selected subjects

The nutritional knowledge questionnaire (Annexure IV) consisted of 25 questions of multiple-choice, 10 attitude questions, and 10 nutritional practices questions. All the 500 adolescents are given questionnaire and are asked to mark the correct answer. Each correct answer is scored and the total score obtained by each adolescent is noted down in order to test their initial nutritional knowledge. From them, about 25 % (125) adolescents who secured low scores (Less than 40 percentage) are selected for nutrition education.

3.4.1. Preparation of teaching aids

Teaching aids such as charts, brochures and power point slides (Annexure V) were prepared and used for imparting nutrition education. Education about nutritional requirements of adolescents, health benefits of breakfast, role of snacking behavior, health hazards of fast foods and role of media on food preferences among the adolescents were imparted to them in convenient batches. Before starting of the nutrition education programme, all the 25 percent of adolescents are collected in a big class room and are given nutrition education with the help of different educational aids; all the basic concepts related to nutrition are taught followed by interactive season.

3.4.2. Assessment of final nutrition knowledge

The questionnaire, which was used to assess the initial nutritional knowledge, was used to test the final knowledge at end of the education period (one week). The difference between the initial and final scores was assessed to find the impact of the nutrition education.

3.5. Statistical analysis of the data

The data was compiled and analyzed by using statistical methods. Descriptive statistics mean and SD, ANOVA, Paired comparison test are computed using a statistical software SPSS version 15.0. Duncan’s multiple range tests were applied to determine the significant differences between samples. Design Expert version 7.0 was used to analyze the optimization techniques.