Project Report

on

EFFECT OF NUTRI DENSE PACK ON ACADEMIC PERFORMANCE AND IMPARTING CHANGEABILITY ON SNACKING PATTERN OF ADOLESCENTS

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Principal Investigator

Mrs.M.THAMARAI SELVI
Assistant Professor
Department of Nutrition and Dietetics
PSG College of Arts and Science
Coimbatore

PSG COLLEGE OF ARTS AND SCIENCE
An Autonomous College - Affiliated to Bharathiar University
Accredited with A Grade by NAAC (Third cycle)
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An ISO 9001: 2015 Certified Institution
Coimbatore -14

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CHAPTER 1

INTRODUCTION

WHO identifies adolescence as the period in human growth and development that occurs after childhood and before adulthood, from ages 10 to 19 years. Today there are 1.2 billion adolescents, worldwide. Nearly 90 per cent live in developing countries. Adolescents make up about 18 % of the world's population. More than half of all adolescents live in Asia. In absolute numbers, India is home to more adolescents (around 243 million) than any other country (UNICEF, 2012).

Adolescents is one of the most dynamic and complete transition in one's life span. The physical development and social changes that occur during adolescence can markedly affect eating behaviours and nutritional health. Rapid physical growth creates an increased demand for energy and other nutrients during adolescence which are higher than any other time in the life cycle (Story, 2002).

Adolescents are considered to be a nutritionally vulnerable segment of the population. Due to enhanced growth during adolescence, the requirement of some minerals is of paramount important. A rapid growth rate combined with a marginal nutrient intake increases the risk of nutritional deficiencies in this population (Ahmed *et al*, 2008). Poor nutritional status during adolescence is an important determinant of health outcomes at a later stage of life. Therefore attention should be given to adolescent health and nutrition (Kabir *et al*, 2010).

Inadequate nutrition in adolescence can put them at high risk of chronic diseases particularly if combined with other adverse lifestyle behaviours. Malnutrition denotes impairment of health arising either from deficiency or excess or imbalance of nutrients in the body (Ghai *et al*, 2008). Children will fail to make any significant progress in their physical as well as mental, emotional and social development, and even put to death, if they are malnourished, so nutrition will always be at the top of any list of priorities for child well-being (Bae, 2008).

Children and adolescent populations are very sensitive to inadequate nutrition (Whitney and Rolfes, 1999). Teenagers make many more choices for themselves than they did as children (Glanz *et al* 1998). At the same time, social pressure thrusts choice at them. The consequences of these choices will influence their nutritional health both today and throughout their life (WHO, 1998).

Food containing five key nutrients is prerequisite for complete nutrition, which can be obtained by taking regular meals without skipping. Meal skipping, and its following food insufficiency and malnutrition are critical for children and young adolescents who are in the stage of physical, mental, and emotional development. Studies confirm that salient adverse effects of insufficient food intake are health problems such as headache and stomach ache, overweight or obesity, underweight, chronic asthma, and iron deficiency (Casey *et al*., 2005). Further, children of food insufficiency reveal academic performance, psychosocial well-being and health-related quality of life greatly lower than those of food sufficiency (Casey *et al* 2005 and Eisenberg *et al*., 2004).

Snacking is commonly associated with undesirable health outcomes and dietary patterns. Since children and adolescents select snacks based on taste over nutrition, they more often choose salty, crunchy foods as snacks over healthier alternatives (Cross *et al*, 1994). Consequently, snacking is commonly regarded as a contributing factor in the development of childhood overweight and obesity, although studies that have examined the association between snacking and body mass index have yielded mixed results (Kubik *et al* 2005 and Howarth *et al* 2007). Although evidence is limited, snacking may also be associated with less frequent consumption of meals, which may be detrimental to health since regular meal patterns are associated with greater dietary diversity (Cusatis and Shannon, 1996), healthier food choices (Haapalahti *et al* 2003) and better nutrient intakes (Neumark-Sztainer, 2003 and Sjöberg *et al* 2003).

The context of snacking in adolescents, or how snacking may influence other dietary habits, such as meal skipping are very little. A number of research showed that snacking among children and adolescents occurs most often in the afternoon and at home (Cross *et al* 1994 and Adair and Popkin, 2005), however information about the specific contexts in which adolescents snack (e.g. while doing homework or working, while watching television) is lacking. Similarly, while meal skipping has been shown to be associated with a higher

snacking frequency among both adolescents and adults (Nicklas, 1998), yet no study has yet explored whether snacking is associated with a higher frequency of meal skipping.

The usual perception on snacking is that snack foods are high in fat and sugar and hence harmful and not conducive for healthy eating (Astrup *et al.*, 2006). In general, snacking can be defined as food or drink eaten between main meals (Chaplin and Smith, 2011) and also based on the time criterion (Gregori and Maffeis, 2007). Adolescents tend to select snacks based on taste over nutrition, and they more often choose salty and crunchy foods as snacks over healthier alternatives (Nicklas, 2003).

Bakery products are much popular than other processed foods because products are convenient to carry, inexpensive and hygienically prepared in ready to eat form. In recent years bakery products have become popular among different cross sections of population due to increased demand for convenience products, shift in eating habits and better transport and distribution method (www.niir.org). Many healthy bakery items have been developed for specific health conditions e.g. sugarless bakery products, multigrain bread, wheat bread etc are made for the diabetic patients (Neelam, 2005). Mushrooming growth of fast food joints serving fancy bakery products like bread-butter, pizza, burger, puff, hotdog, pastries etc. along with traditional bakery products like biscuits, cookies, cakes etc. is the indication that bakery industry has developed in its own remarkable position in the industrial map of India (Kamliya, and Rema 2003).

Cookies are not considered as staple food as bread, but may be feasible fibre carrier because of their long shelf life and thus enable large scale production and widespread distribution. In many countries, cookies are prepared with fortified or composite flour to increase its nutritive value (Gonzalez – Galan *et al.*, 1991).

Cookies consumed all over the world as a snack food and on a large scale in developing countries where protein and caloric malnutrition are prevalent particularly among women and children(Chima, 2007).Cookies can serve as a vehichle for important nutrients if made readily available in the population.

Similarly, extrusion cooking has been investigated as a means of producing snacks that can be tailored to meet the dietary requirements of particular groups of the population. The work of Siegel and Lineback (1976) identified extrusion as a useful process in respect of the

development of a high protein snack to overcome issues of protein malnutrition in the developing world. Ibanoglu et al (2006) and Stojceska et al (2010) investigated the use of extrusion to produce snacks meeting the dietary needs of those on a gluten free diet. Extrusion has been investigated as a means of improving the nutrient profile for example increasing levels of dietary fibre (Stojceska et al. 2010) and enriching foods with nutrients such as lycopene (Shoar et al 2010).

Millets are rich in vitamins, minerals, sulphur- containing amino acids and phytochemicals, and hence are termed as nutri-cereals. They have higher proportions of non starchy polysaccharides and dietary fibre. Millets release sugars slowly and thus have a low glycemic index. They have been designated as 'nutritious millets' (Bala , 2004). Thus, millets were utilized for the development of commonly used cookies and RTE snacks in the present study.

Most adolescents are present-oriented, which means they are generally not concerned about how their current eating habits will affect their future health status but are concerned about their physical appearance, maintaining a healthy weight and having plenty of energy. While teenagers should give consideration to the potential long-term risks of an unhealthy diet and the likely benefits of healthy eating habits, focusing on short-term benefits is more likely to make a lasting impression on adolescents and facilitate dietary change. Very little attention has been paid to adolescents so far and adolescent nutrition has received inadequate attention in research as well as in programming for adolescent health. If adolescents are well nourished, they can efficiently focus their energies onto their skills and talents, be healthy citizens and responsible parents and good mentors for future generation. To accomplish such a task, a special focus for overcoming malnutrition in adolescence is needed, in order to break the intergenerational cycle of malnutrition(WHO, 2002). Considering this a study will be conducted among young adolescents in Coimbatore to study the meal, snacking pattern and to test the efficacy of developed food supplement on their nutritional status.

Broad objective:

To study the effect of nutri dense pack on the academic performance and imparting changeability in the snacking pattern of adolescents

Specific objectives:

- To examine the meal pattern and snacking pattern of the adolescents
- To assess the nutritional status of the adolescents
- To develop a nutri dense food supplement pack
- To find out the effect of nutri dense pack on nutritional and health status of the selected participants.
- To study effect of nutri dense pack on academic performance of the selected participants.
- To impart changeability on snacking behaviour of adolescents

CHAPTER II

REVIEW OF LITERATURE

The review of literature pertaining to the study entitled "**Effect of nutri dense pack on academic performance and imparting changeability in the snacking pattern of adolescents**" are presented under the following headings

2.1 Snacking pattern of school students
2.2 Multigrain cookies
2.3 RTE snack

2.1 Snacking pattern of school students

Snacks could be defined as consumption of foods and drinks between meals such as milk drinks, regular soft drinks, sports drinks, and energy drinks (Savige, MacFarlane, Ball, Worsley, & Crawford, 2007). These snacks may be consumed at different times in a day: morning, afternoon, or evening (Bellisle, 2004). The numbers of daily snacks may differ from area to area (Savige, MacFarlane, Ball, Worsley, and Crawford, 2007). Snacks may provide up to one quarter of the daily energy intake in some adolescent populations; for example, the snacks of American adolescents, aged between 12 to 18 years, provided approximately 25% of their daily energy intake (Savige, MacFarlane, Ball, Worsley, & Crawford, 2007).

Snacking is likely to play an important role in the development of overweight and obesity, yet little is known about the contexts of snacking in adolescents or how snacking may influence other dietary habits, like meal skipping. This study examines the contexts in which adolescents snack and whether these contexts are associated with demographic characteristics of adolescents and with meal skipping. These data suggest adolescents snack frequently, especially in their leisure time. In addition, adolescents who snack on the run, on the way to or from school, all day long or in the middle of the night are more likely to skip meals than are adolescents who don't snack at these times. Understanding the contexts in

which adolescents snack, and their associations with skipping meals, may assist those involved in the promotion of healthy food habits among adolescents. (Gayle et al, 2007).

In Nepal, a study among school children revealed that fast foods (ready-to-eat snacks, chips, etc.) were referred by more than two-thirds of them and that advertising influenced preferences in 80% (Sharma. 1998). A study by Punjab Agricultural University, Ludhiana, on consumption pattern of fast foods among teenagers found that fast foods are most commonly consumed between regular meals (Sadhana, 1997).

Irregular meal patterns and the consumption of high calorie snacks are becoming common which may contribute to being overweight and being obese in college populations. In the Lebanese American University campus during the fall of 2006, the students *(N* = 220) aged 20± 1.9 years of age were asked to complete a self-reported questionnaire that included questions about eating and drinking habits, weight, and height. After the data analysis, the percentage of the normal BMI students was 64.7%. The percentage of overweight and obesity among male students was *(37.S%* and *12.S%,* respectively), which was higher than female students (13.6% and 3.2%, respectively) (Yahia, Achkar, Abdallah, & Rizk, 2008).

A different study also assessed snacks both in energy intake and foods consumed. The method used in this study was a diary of food and snack intake for four, 7 -day periods. The participants were 54 French adults. After the data analysis, the mean of main meals was 2.7 meals a day, and the mean number of snacks was 1.3 a day. There were a very few days when no snacks were consumed. The total daily energy and macronutrients were the same amount in the days with snacks or without snacks. Macronutrient contents of fat and protein were higher in meals compared to snacks. The snacks contained more carbohydrate (sweets, cereal bars, biscuits, and sodas) and less fat and protein (Bellisle et aI., 2003).

Teo et al (2012) evaluated the snacking patterns and also to assess whether snacking frequency is associated with energy and nutrient intakes, as well as BMI among the adolescents. Body mass index was assessed by anthropometric measurement with height and weight measurement. The snacking patterns were evaluated with questionnaire while dietary data was collected by food frequency questionnaire (FFQ) and one-day 24-hour diet recall. A total of 156 adolescents aged 13-15 years old from two secondary schools in Kuala Lumpur were involved in this study. Results showed that most respondents (48.7%) consumed snacks

once a day. More than half (64.7%) of them reported having afternoon snack and the most common context for snacking were while watching television (59.6%). The most frequently consumed snacks included fruits, sweets, breads, milk, soft drinks and caffeinated beverages. The most common meal and snacking patterns in majority (23.1%) was composed of three main meals plus two snacks per day. There was significant difference between meal and snacking patterns and energy and macronutrients intakes ($p<0.05$). A total of 24.4% of daily energy intake came from snack consumption, while the energy contribution of protein, carbohydrate and fat intake from snacks were 18.7%, 26.6% and 23.7% of their daily energy intakes, respectively. More frequent snack intake contributes to higher energy intake. Moreover, the more frequent snack intake, the more carbohydrate intake from snack as compared to protein and fat intake. However, there was no significant association between snacking patterns and BMI. In conclusion, these findings indicated that snacking patterns was associated with energy and nutrient intakes but no association with BMI among the respondents.

2.2 Multigrain cookies

Hima Bindu and Sumathi (2003) prepared common Indian traditional products namely muruku, chegodi, dosa, chapathi, laddu and payasam by incorporating Foxtail millet. All the products were acceptable. It was suggested that nutritious Foxtail millet could be exploited for the nutritional benefits and value added nutritive health foods.

Naz (2000) and Gambus *et al* (2004) reported that the breads containing 10 and 13per cent levels of linseeds were characterized by higher amounts of protein, fat, dietary fiber, macro and microelements in comparison to standard bread. There was a significant increase in Fe, Zn and Mn contents of the bread with the increasing level of flax seed flour in the wheat flour.

Proso-millet based convenience mix for infants and children was developed by Srivastava *et al.* (2001) by malting and popping techniques. The convenience mix (100g) provided 14.32 g protein, 82.48 mg calcium, 4.20 mg iron, 8.84 mg ascorbic acid and 63.90 mg b-carotene per 50 g of the mix. Sweet and salt gruels, *halwa, burfi* and biscuits based on the convenience mix were reported to be organoleptically acceptable.

Barnyard and finger millet based *khichadi, laddu* and *baati* were prepared along with legumes and fenugreek seeds by Arora and Srivastava (2002). *Khichadi* was prepared with millet, whole green gram and fenugreek seeds in a ratio of 60: 20: 20 respectively. *Laddu* contained millet, roasted soybean and malted fenugreek seeds in the proportion of 65: 10: 20 along with 5 per cent popped amaranth seeds. Millet based baati was prepared with millet, fenugreek seed powder and roasted Bengal gram flour in the ratio of 60: 20: 20. All the products were acceptable. Carbohydrate content in finger millet based khichadi, laddu and baati provided 56.47, 81.71 and 79.32 per cent of total energy, whereas the Barnyard millet based khichadi, laddu and baati, it provided 51.59, 79.40 and 67.76 per cent of total energy, respectively.

Finger millet based pasta products with good cooking quality, storage stability, acceptability and higher nutritive values were developed by Devaraju *et al.* (2003). Composite finger millet flour (50%), refined wheat flour (40%), defatted soy/whey protein concentrate (10%), and hot water (75°C) were used for pasta making. The mean protein, energy, calcium and iron in the experimental pasta ranged from 14-18 g, 365-372 k cal, 102-148 mg and 3-5mg respectively.

Barnyard and Kodo millet based chapathi and dosa and two commercial products viz., noodles and rusk were developed by Poongodi *et al.* (2003). Millet along with wheat flour and defatted soy flour in varying proportions were used. The acceptable levels of incorporation of millet flour were reported to be 20% for noodles and 30 per cent for rusk, chapathi and dosai.

Shanthi *et al.* (2005) studied on the effect of incorporation of Finger millet in pasta products. Refined wheat flour, whole wheat flour and soya flour were blended with finger millet in different proportions, with wheat and refined wheat flour as the main ingredient. Sensory evaluation revealed that incorporation of Finger millet up to 30% and soya flour up to10 per cent was acceptable.

Veena *et al* (2004) explored the substitution of Barnyard millet in five cereal based traditional foods viz., rice, roti, dosa, idli and chakli. These were prepared by different cooking methods like boiling, pan-baking, fermentation, shallow and deep fat frying. The main ingredient of the selected food (except for cooked rice) was substituted with Barnyard millet flour in varying levels of 0, 25, 50, 75 or 100 per cent. It was reported that the substitution improved the nutrients per serving in terms of dietary fibre and minerals but

reduced the calorific value. It was suggested that Barnyard millet could be used in most common cereal based traditional foods.

2.3 RTE snacks

Geeta *et al* (2012) stated that Kodo-chickpea flour blend gives desirable crispy extrudates at higher screw speed 280 rpm, lower feeder speed 20 rpm, and medium to high temperature 123 °C. Effect of intermediate and highest process conditions did not very much on their effect on proximate content.

Arun Kumar *et al* (2015) analyzed the effect of processing variables on the responses of extrudates manufactured from different blends of sorghum and soybean. The models were found to be statistically valid and provided adequate information regarding the behavior of the responses upon variation in the processing variables. The results showed that various levels of soybean could be incorporated into extruded sorghum based snacks depending on the desired qualities in the product He confirmed the feasibility of developing nutritious snack food from sorghum-soya by extrusion processing.

Kavya reddy *et al* (2014) demonstrated the utilization of roots and tuber flours as potential and diverse ingredients to enhance the appearance and nutritional properties in RTE extruded snack. The overall acceptability of RTE extruded products made with potato and taro were highly acceptable compared to yam and sweet potato.

Elina *et al* (2013) developed ready to eat (RTE) products using sweet potato (*Ipomoea batatas*) and greater yam tubers (*Dioscorea alata*). Both the extruded ready to eat products of rice incorporated with sweet potato powder and yam powder have shown to possess good functional properties and desirable nutritive value and is concluded that nutritionally enhanced breakfast cereals can be made from rice-sweet potato extrudates and rice-yam extrudates with addition of minerals and vitamins.

Manisha and Uday 2013**,** indicated that sorghum can be extruded to produce ready-to-eat snacks with good organoleptic acceptance. The physicochemical properties and sensory characteristics of sorghum-based extrudate were dependent on process variables, like particle size, moisture content, feed rate, screw speed and barrel temperature. Extrusion process

significantly increased dietary fibre with decrease in content of starch, and tannin. All three varieties were extruded using same experimental conditions of feed moisture 22percent, barrel temperature 130 °C, screw speed 210 rpm and feed rate 70 g min-1. The sensory evaluation showed that extrudate having 0.49 mm particle size was the most acceptable.

Norfezah Md Nor *et al* (2013) developed ready-to-eat snacks by extruding corn grits with 5percent, 10percent, 15percent and 20percent of pumpkin flour. Although, the texture of this product was about 40percent harder than for typical corn based products the bulk density was similar up to the addition of 15percent of pumpkin flour and illustrated that snack foods can be produced from combinations of corn grits and pumpkin products.

Priyanka *et al*, (2012) prepared extruded snacks using flour blends of corn, rice and egg albumin powder or Cheese powder at ratios of 35-50: 35-50: 5-30 respectively and moisture content was adjusted to 17-20 and showed that incorporation of egg albumin powder and cheese powder can be effectively used to produce RTE extruded snacks by extrusion cooking. Such ingredients naturally improved the nutrient content of the snacks. The protein content in the RTE extruded snack was found to be doubled on addition of egg albumin powder, and to a substatial extent by cheese powder. A 100 g serving would likely contribute 20percent – 40percent of the RDA for protein providing an an effective solution for people consuming protein deficient diets.

Dibyakanta and Gopirajah (2012) studied the effects of amount of ingredients such as ragi (40–50 percent), sorghum (10–20 percent) and soy (5–15 percent) on the physical properties like bulk density, expansion ratio, water - absorption & solubility index of snacks. The basic formulation for production of millet-based extruded snack with desired sensory quality was obtained by incorporating with 42.03 percent ragi, 14.95 percent sorghum, 12.97 percent soy and 30 percent rice.

Deshpande and Poshadri, (2011) focused their study on the use of Foxtail millet (*Setaria italica*) along with other flour for production of ready-to-eat snack products using extrusion cooking and revealed that composite flour (Foxtail millet; Amaranth; Rice; Bengal gram; Cow pea in the ratios of 60:05:05:20:10) could be used to produce quality extrudates with acceptable sensory properties.

CHAPTER III

METHODOLOGY

The methodology pertaining to the study entitled "**Effect of nutri dense pack on academic performance and imparting changeability in the snacking pattern of adolescents**" are presented under the following headings

3.1 Snacking pattern of school students

3.1.1 Selection of locale

3.1.2 Drafting of questionnaire

3.2 Development of nutri dense snack

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3.2.2 RTE crispy snack

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3.3 Effect of nutri dense pack on selected school children

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3.3.3 Academic performance

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3.4 Imparting changeability through nutrition education

3.1 Snacking pattern of school students

3.1.1 Selection of locale and sample

During the transitional period of young adulthood, following a healthy lifestyle behavior can have a long lasting effect on personal and family health. It is vital for young adults to be educated and reinforced with healthy eating behaviours for them to make healthy food choices in the future. These healthy eating food habits can be sustained into the future to combat life-style related diseases such as diabetes mellitus, hypertension and coronary heart

disease. Irregular meal patterns and the consumption of high calorie snacks are becoming common which may contribute to being overweight and being obese in adolescent population (Moy *et al* 2009).

A community based cross-sectional study was conducted among the school children. Permission to conduct the study was obtained from the school authorities. Three schools from Coimbatore were selected randomly. Students in the grade 10, 11 and 12 from each school were selected to conduct survey. Eligibility criteria were those who were present, age 16 - 19 years and those willing to participate. The class teacher and students were briefed about the study and were interviewed only after obtaining verbal consent. All of them were given questionnaire for self administration, however 3 students did not return the questionnaire and 8 students gave incomplete response. Thus, 150 students could be finally considered for analysis. Data was collected using a pre-designed, pretested semi-structured questionnaire on socio-demographic variables, meal pattern and snacking habits. Translation of questionnaire in Tamil language was done by language experts.

3.1.2 Drafting of questionnaire and collection of data

Considering the importance snacking pattern, self administered questionnaire was framed to assess the snacking pattern among school students. The questionnaire handed out consisted of two sections. The first section covered basic demographic data such as age, sex, residence, family type, family size, parents' occupation, monthly income second section gathered the information on meal and snacking pattern (type, time and frequency).

Initially, a pilot study was carried out to test the reliability of the questionnaire among 50 participants. The pretested questionnaire was further reframed and used to collect necessary data. The details regarding each and every question was clarified and cleared before administering the questionnaire to the students. Data was collected by giving adequate time and instructions to gather reliable information. Questionnaire is appended in Appendix I.

3.2 Development of nutri dense pack

Selection of ingredients

Wheat (*Triticum aestivium*) – Wheat is regarded as a potential source of proteins, dietary fibres, minerals, and B-group vitamins. Wheat provides nearly 55 percent of carbohydrate and 20 percent of the food calories. It contains 78.10 percent of carbohydrate, 14.70 percent of protein, 2.10 percent of fat and considerable proportions of vitamins (thiamine and vitamin-B) and minerals (zinc, iron, selenium and magnesium) (Kumar *et al*, 2011).

Sorghum (*Sorghum bicolour* L. Moench) is one of the major cereal crop consumed in India after rice (*Oryza sativa*) and wheat (*Triticum aestivium*). Sorghum is commonly called as jowar or great millet. Sorghum is poor in lycine but rich in leucine. Nutritional importance of sorghum is 349 Kcal energy, 9.6 per cent protein, 3.8 per cent fat, 73.2 per cent carbohydrates, 2.4 per cent ash and 11 per cent moisture content. Sorghum protein is superior to wheat protein in biological value and digestibility. Sorghum is totally free from gluten, contains more fibre and micronutrients.

Finger millet (*Eleusine coracana*) is a traditional and economical crop rich in protein, iron, calcium, phosphorous, fibre and vitamin content. It contains about 5–8 percent of protein, 1–2 percent of ether extractives, 65–75 percent of carbohydrates, 15–20 percent of dietary fibre and 2.5-3.5 percent of minerals (Chethan and Malleshi 2007). IT also possess a high calcium content among all cereals (334 mg/100g) It also contains phytates (0.48 percent), polyphenols, tannins (0.61 percent), trypsin inhibitory factors and dietary fibres that are considered as neutraceuticals. The seed coat of millet is an edible component of the kernel and is a rich source of phytochemicals such as dietary fibre and polyphenols (Palaniswamy *et al*, 2014). Ragi has gained importance because of its functional components, such as slowly digestible starch and resistant starch. Ragi provides nutrients like Vitamin C, phosphorous, lysine and tryptophan (Varsha and Pavani, 2016).

Pearl millet (*Pennisetum typhoideum*) contains substantial amount of minerals such as iron, calcium, zinc and high level of fat, it is nutritionally comparable and even superior to major cereals due to the energy and protein value.It is nutritious but underutilized in developed countries due to non-availability in convenient/ ready to eat form (Obilana, 2004).

Legumes have been known as ‘‘a poor man’s meat’’. They supply protein, complex carbohydrates, fibre and essential vitamins and minerals to the diet, which are low in fat and sodium and contain no cholesterol. Legumes have been identified as low glycaemic index food. In addition to nutritional importance, they are also being recognized as having therapeutic and medicinal properties. Legume proteins are fortified with lysine and sulphur containing amino acids, whereas cereal proteins are found to be lacking enough amounts of lysine but have adequate amounts of sulphur amino acids. Therefore, the combination of grain with legume proteins would provide better overall essential amino acid balance helping to overcome the world protein calorie malnutrition problem (Kadam *et al*, 2012).

Chickpea (*Cicer arietinum*) are one of the most widely consumed pulses in the world and protein content varies from 21.7 to 23.7 percent (El Adawy, 2002). Chickpea proteins are rich in lysine and arginine but scarce of methionine and cystine. It contains twice the amount of protein than that of cereals; hence it can balance the amino acid and may improve the nutritive value of a cereal based diet. It has high protein, cellulose and mineral content and is low in fat and calories. Roasted form of chickpea is characterized as a healthy snack with potential use as a natural “functional food” due to its chemical composition.

Mung bean, (*Vigna radiata L*.) It is third major edible legume next to chickpea and cow pea in terms of production and consumption pattern. It is a source of micronutrients, minerals and easily digestible quality proteins in a cereal based diet and contributes to a balanced diet for the people belonging to low economic groups. It is highly recommended in a human diet to fulfil its protein need. (Riaz *et al*, 2014).

Soybean is another major crop of the tropics, apart from its ability to strive in the tropical climate; is a health plant due to good content of plant-proteins and other phytochemicals (Aleke *et al*, 2000). The FDA says that 25 g of soy protein per day can reduce the risk of coronary heart disease (Jan Pokorny *et al*, 2002).

Peanuts or Groundnuts *(Arachis hypogeal)* are one of the largely cultivated legumes all over the world. Peanuts are often referred as poor man’s protein but, when taken in adequate amounts in any form, will supplement rich nutrients to the body that can provide growth and energy, and play a vital role in the prevention of diseases. These include carbohydrates, lipids, proteins, vitamins, minerals, some organic acids and purines. (Settaluri

et al, 2012). In addition to milk and eggs another vital source of protein is peanuts. Peanuts contain all the essential amino acids necessary for normal body growth and metabolism (Hoffmann and Falvo, 2004).

Ingredients used for cookie preparation

S.No	Ingredients (g)	Standard (WF)	V_1 (SF)	V_2 (PF)	V_3 (FF)	V_4 (SPF)
1.	Wheat flour	100	60	60	60	50
2.	Sorghum flour	-	20	-	-	10
3.	Pearl millet flour	-	-	20	-	10
4.	Finger millet flour	-	-	-	20	10
5.	Roasted Bengal gram flour	-	5	5	5	5
6.	Green gram flour	-	5	5	5	5
7.	Soy flour	-	5	5	5	5
8.	Groundnut flour	-	5	5	5	5
9.	Sugar	50	50	50	50	50
10.	Fat	50	50	50	50	50
11.	Essence (tsp)	1	1	1	1	1
12.	Baking powder (g)	1	1	1	1	1

Standard – 100 per cent Refined Wheat flour
Variation I (SF) – Sorghum flour
Variation II (PF) – Pearl millet flour
Variation III (FF) – Finger millet flour
Variation IV (SPF) – Sorghum : Pearl millet : finger millet

All the cereal and millet flakes were roasted till it reaches 60°C to retain the crispness and ground to coarser particle in mixer. Pulses were roasted and pulverized to powders, groundnut and sesame seeds were roasted to enhance the flavour and coarsely ground using mixer.

3.2.1 Development of multigrain cookies

Screening of composite flour for baking

There are several methods of mixing applicable to cookie-making. The common methods of mixing ingredients in cookie-making are as follows:

Sifting – Dry ingredients such as flour, salt, baking powder and sometimes sugar are passed through a sifter. This method allows blending of ingredients and at the same time removing coarse particles producing uniform, even size particles for easy blending with the liquid.

Creaming – Shortening is creamed while sugar is added gradually. The mixture becomes light and spongy due to the air that is incorporated in the mixture while creaming.

Mixing – The process of combining ingredients to allow the even distribution of dry ingredients

Rolling – This is the process of further mixing or smoothing of dough by laying it flat on the table and allowing a rolling pin to pass over it in a forward-backward motion. Rolled, pressed, and molded cookies are generally rolled before they are cut into any desired shape and size.

Cookies are usually laid on greased trays. They are arranged about 1.5 to 2 inches apart from each other. This space allows for proper expansion of the volume when heated.(Bake in preheated oven at 180°C for 10 mins) The oven is usually preheated prior to baking to allow for an equal distribution of heat inside the oven. This in turn gives equal heat penetration in the product. Bake, cookies for 15mins in an oven at 180°C. as soon as the cookies are removed from the oven, allow them to cool. Preparation of cookie is given in figure –I.

Preparation of Cookies

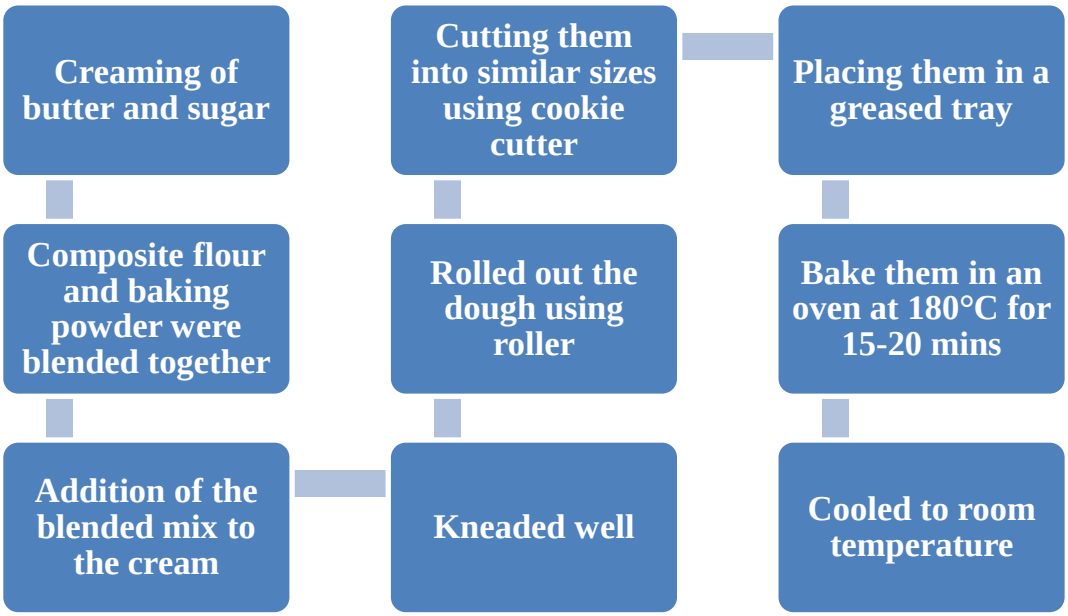
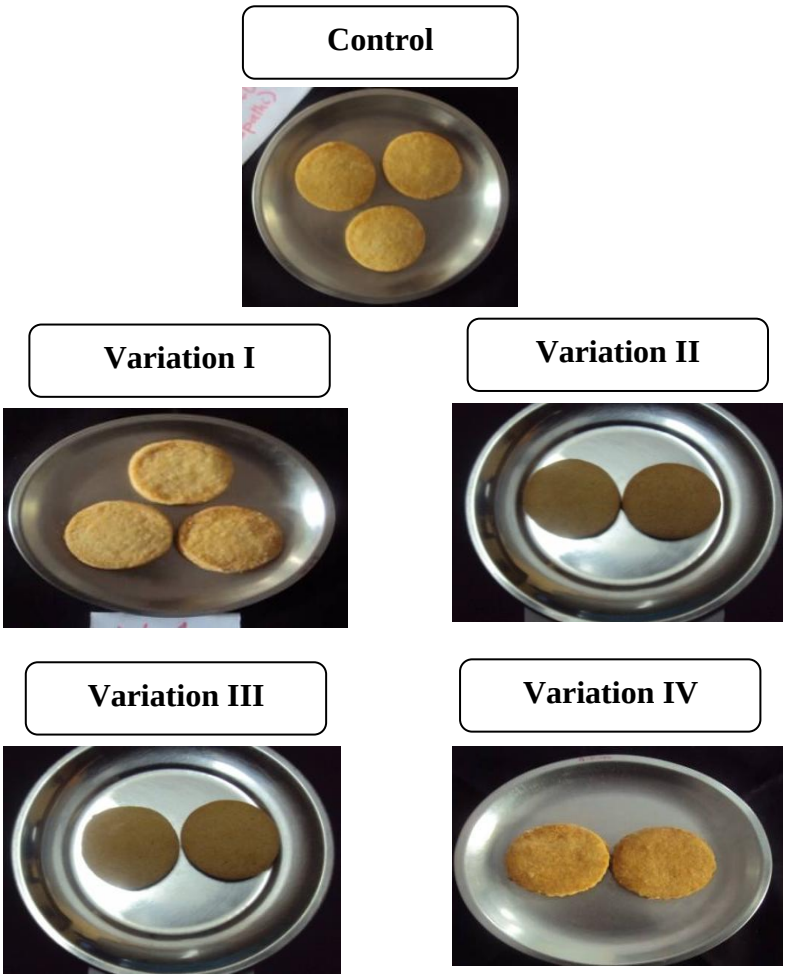


Plate – II

Formulated multigrain cookies



3.2.2 Formulation of RTE crispy snack

Selection of ingredients

Millets have traditionally been a part of Indian diets though in recent years people have shifted to cereals due to various reasons.. The quality of proteins is synergistically increased in cereal-legume mixes owing to the lysine from the legumes and methionine from the cereals (Bressani and Elias, 1980). The most used raw materials in the extrusion process are starch and protein based materials such as rice, wheat, maize and soybean. The raw materials undergoing the extrusion cooking processes includes various combinations of ingredients such as cereals, grains and starches, tubers, legumes, oil seeds, cereals as well as animal fat and proteins (Ilo *et al*2000). The physical structure of the extruded products may be as a result of the presence of starch or protein polymers. The process included are structure forming, facilitating physical transformation during the extrusion-cooking, affecting the viscosity of the material and its plasticization, facilitating homogeneity of the dough ingredients, accelerating starch melting and gelatinization and improving the taste and (www.lamolina.edu.pe) colour of products (Moscicki, 2011).

Following ingredients were selected on the basis of starch content which is a major component in the formulation of extruded products. Grains like wheat (*Triticum aestivium*), sorghum (*Sorghum vulgare*), Finger millet (*Eleusine coracana L.),* Pearl millet (*Pennisetum typhoideum*), Roasted Bengal gram (*Cicer arietinum*) and Green gram (*Phaseolus aureus*) were procured from local wholesale market. Defatted toasted soya flour (*Glycine max*) was procured from Sakthi Soya Company, Pollachi, Tamil Nadu.

Formulation of crispy snack

Preparation of composite mix for extrusion

The selected grains were cleaned to remove any stones and extraneous matter, conditioned and milled using hammer mill and sieved to have uniform mesh size of 60 mm. They were mixed in the different ratios on a dry to dry weight basis as per the following. The samples were blended in the following ratio

Control = 50% Rice and 50% maize

Variation I = 90 % Cereals: 10% Pulses

Variation II = 80 % Cereals: 20% Pulses

Variation III = 70 % Cereals: 30% Pulses

Formulation of RTE crispy snack

Ingredients (g)	Control	Variation I	Variation II	Variation III
Rice	50	-	-	-
Maize	50	-	-	-
Wheat	-	60	50	40
Sorghum	-	10	10	10
Finger millet	-	10	10	10
Pearl millet	-	10	10	10
Roasted Bengal gram	-	5	10	15
Defatted toasted Soya flour	-	5	10	15
Total	100	100	100	100

The blended samples were brought to 15% - 20% moisture by spraying with a calculated amount of water and integration in a blender at a medium speed. The samples were packed in polythene bags and stored at 4˚C overnight. The feed material was kept as such for 3 hours to bring the material to room temperature prior to extrusion.

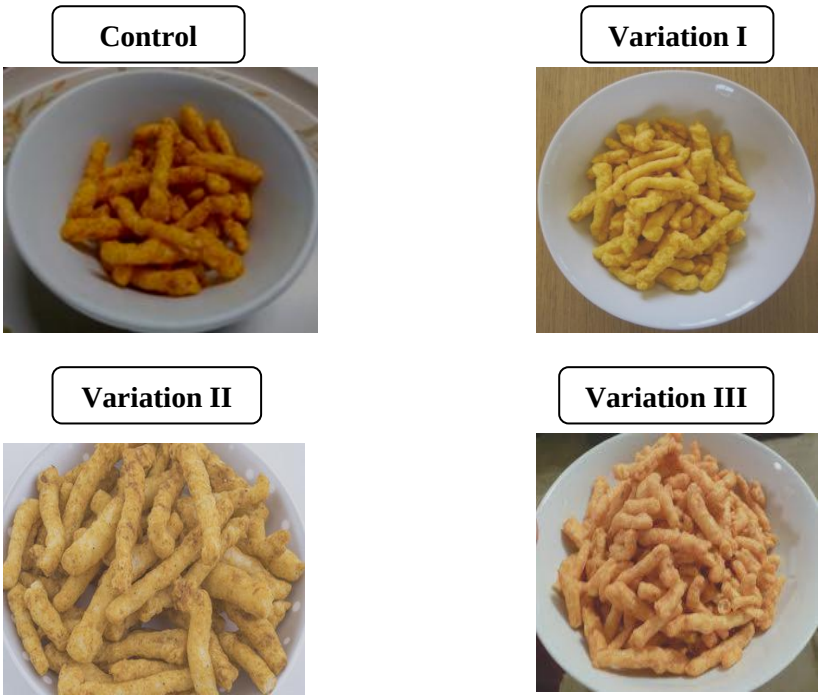
From the results of the preliminary study, experimental design and conditions, millet and legume flour were mixed at 60 (millet mix):40 (legume mix) ratios. Product prepared from rice and corn at 50 percent served as control.

Selected sample was conditioned to 20– 22 percent moisture by spraying a calculated amount of water and mixing continuously at a medium speed in a blender. The samples were then packed in polythene bags and stored at 4˚C overnight. The feed material was allowed to thaw for 3 h at room temperature to equilibrate the temperature throughout the sample.

Preconditioned sample was fed into an extruder hopper. They were extruded at a temperature of 80±5°C (Heater 1) and 100 ± 10°C (Heater II) with a screw speed of 350 rpm,

feed rate of 15 kg / hr, the exit diameter of circular die was 2 mm. The cutter speed was set at 100 rpm.

The extrudates were sprayed with hot (80 °C) refined sunflower oil (50 ml / kg of extruded snacks). After thorough mixing of puffs with oil, a standardized spice mix (Tomato powder, chilli powder and salt at 2.5 % each) was sprinkled to ensure proper coating on each individual puff. The spiced extrudates were dried for 15 min at 60°C to have better crispness in the final extruded product.



3.2.3 Organoleptic evaluation of formulated nutri dense pack

An organoleptic quality was a combination of different senses of perception coming to play in choosing and eating a food. Sensory evaluation evokes, measures, analyses and interprets responses to the given products as perceived by the senses including smell, sight, touch, taste and hearing (Stone and Sidel, 2004). Among these most applied methods used to measure acceptance of products is the hedonic scale, in which consumers express their acceptance following a pre-established scale, which gradually varies based on terms such as like and dislike (Silva *et al* 2005). Sensory score card was given in appendix II & III.

3.2.4 Quality characteristics of nutri dense pack

Physiochemical characteristics of nutri dense pack

Moisture

Water, a major component of food plays an influential role on the texture, appearance, taste and spoilage of food products. It is also necessary to calculate the content of other constituents of food. The remaining dry matter after moisture analysis is referred to as the total solids (Suzanne, 2010). Moisture content of the health mix was determined as given in Appendix IVa.

Ash

The term ash refers to the inorganic residue left over after either combustion or complete oxidation of the organic matter present in the foodstuff. Dry ashing is the use of a muffle furnace which is capable of maintaining temperatures of 500-600°C for the process of ashing. The ash content generally represents the total mineral content present in foods (Suzanne, 2010). The ash content of the health mixes were determined as given in the Appendix IVb.

Nutrient estimation of nutri dense pack

The developed instant multigrain health mixes were analyzed for its nutrient composition by using the methods as follows (Appendix IVc to IVi).

Nutrients	**Method**
Protein (g)	AOAC (2000)
Fat (g)	AOAC (2007)
Total carbohydrate (g)	Anthrone method,1962
Fibre (g)	I.S 1155 : 1968
Energy (Kcal)	Calculation method
Iron (mg)	Wongs method
Calcium (mg)	Titration method

3.2.5 Storage stability of the developed nutri dense snack

Storage stability of the developed nutri dense pack was assessed by microbial load and sensory evaluation. Microbial analysis was done for the multigrain cookies and RTE snacks to know their shelf life by packing them in air tight polythene bags and kept for 60 days. The microbial load was observed after 60 days by total plate count. Sensory evaluation was conducted every 15 days on nine point hedonic scale.

3.3 Efficacy of nutri dense pack on school students

Conduct of food intervention study

100 school students were selected and grouped as control and experimental group (supplement group). Developed nutri dense pack was provided to the selected school students as snack to experimental group and control group was provided with plain cookies and

mixture for a period of 90 days. Before starting the intervention period, all the 100 participants were imparted orally about the beneficial aspects of the study and requested to consume the nutri dense pack and cooperate for the study. There was no gender preferences, both male and female students were selected for the study. Details on Food allergies were recorded separately from each individual. Both the groups were monitored for 90 days. Developed nutri dense pack (Two biscuits and 25 g of curls) was selected for food intervention study.

Control group	-	50 (Plain cookies and mixture)
Test group	-	50 (Formulated cookies and RTE crispy snack)

The effect of nutri dense pack on school students was assessed by changes in Body Mass Index (BMI), haematological picture and Intelligence test. Combination of these methods provide better picture on assessment of nutritional status of the target group prior and post supplementation period of 90 days.

3.3.1 Anthropometric measurements of the selected students

Anthropometry deals with the measurement of body at various ages and level of nutritional status. Height and weight were measured using non stretchable measuring tape, glass scale and weighing machine using the standard techniques. Height in centimetres was marked on a wall with the help of a measuring tape. All students were measured against the wall without foot wear and with heels together and their heads positioned so that the line of vision was perpendicular to the body. A glass scale was brought down to the topmost point on the head. The height was recorded to the nearest 1 cm. The subjects were asked to remove their footwear before measuring their weight. The scales were recalibrated after each measurement. Accuracy of the weighing scale was verified after 50 such measurements against known weights. At the end of the study, after collection of the questionnaire from the students, they were satisfactorily addressed about eating habits, nutritional issues and related queries. Headmistress was also given feedback of the study. Data was analyzed using SPSS-16. For descriptive statistics proportion, mean ± SD were used. The mean height, weight and BMI of the selected control and experimental group of school students prior and post intervention period were recorded.

3.3.2 Biochemical indices of the selected students

Haematological indices such as lipid profile, serum protein and haemoglobin were estimated at the beginning and at the end of the intervention period for both groups of school students. The procedure adopted for estimation of blood indices is presented in Appendix VI, VII and VIII.

Biochemical indices	**Method**
Serum protein	Biuret method
Haemolobin	Cyanamet haemoglobin
Total cholesterol	Enzymatic colorimetric method
HDLcholesterol	Phosphotungstate method
Triglycerides	GPO/POD method
LDL cholesterol	Calculated – Formula I
VLDL Cholesterol	Calculated – Formula II

Friedewald's formula
Formula I – LDL Cholesterol = Total cholesterol – (HDL + VLDL)
Formula II – VLDL -= Triglycerides / 5

3.3.3 Academic Performance of the selected students

Academic performance was of the students were assessed by the marks scored by the students in the model test exam conducted by the school every month prior to them being sent up for their quarterly/half yearly exam. Since the students had a combination of subjects, so to bring in parity in assessment, the percentage of the total marks scored by the students in mathematics, physics, chemistry and biology/computer science were taken into consideration to rule out bias. Marks of the students were obtained from their respective class teachers with permission from higher officials. Average marks of the students were categorized as follows; marks below 35 were given D grade, from 35 to 50 as Grade C, marks from 50 to 75 as Grade B and marks above 75 were grade A.

3.3.4 IQ and aptitude test

It is an IQ & aptitude testing tool which contains three sections including ***verbal aptitude, spatial aptitude and numerical aptitude***. One test from each section was used in the

present study. The time limit set for completing each test should not exceeded or else the score was invalid.

Verbal aptitude is the capacity of general lexical skills or understands of words in a language and using them effectively. **Word meaning Test –** measures the ability to distinguish words there are frequently confused with in correspondence and conversastion. This test contains 30 questions to be solved in 30 minutes (Appendix IXa).

Spatial aptitude pertains to space, spatial abilities which mean the perceptual and cognitive abilities which enable a person to deal with spatial relations. **Logical analysis test** - 'logical' analytic or deductive in nature and measures a person's capacity of reasoning in an orderly, cogent fashion. This test contains ten questions to be solved in 60 minutes (Appendix IX b).

Numerical aptitude – Mathematical intelligence tests explore a person's ability to reason and perform basic arithmetic functions. Numerical (mathematical) intelligence is a strong indicator of general intelligence as most of the everyday tasks require the use of arithmetical operations. **Numerical sequence test** - In a numerical sequence test it is necessary to identify a pattern that is occurring in the sequence. The use of a calculator is not permitted in this test. A time limit of 20 minutes is allowed in which to complete 15 questions (Appendix IX c).

All the tests were followed by scoring method with different ratings or levels such as genius, high expert, expert, high average, middle average, low average, borderline low, low and very low based on the scores obtained by the individual.

3.4 Nutrition Education and Statistical analysis

An awareness campaign on nutrition education was conducted among the selected school students. Questionnaire was framed which comprises the questions to assess the knowledge on healthy eating. It consisted of questions that measured the students' knowledge on food groups, nutrients, sources and RDA (15 questions). Students were explained about the questionnaire form before being answered (self-administered) (Appendix X).

Power point slides (Appendix XI) were prepared and used for imparting nutrition education. Education about food groups, nutritional requirements of adolescents, health snacking were imparted to them. Before starting the nutrition education programme, questionnaire was administered to assess the initial nutritional knowledge and the same was

used to test the final knowledge at end of the education period (immediately and after month). The difference between the initial and final scores was assessed to find the impact of the nutrition education.

Statistical analysis - Statistical Package for the Social Sciences (SPSS) version 16 was used for data analysis. Paired t test was used to find the significance difference between before and after supplementation. The level of significance was maintained at one percent level and five percent level.

CHAPTER IV
RESULTS AND DISCUSSION

The results pertaining to the study entitled "**Effect of nutri dense pack on academic performance and imparting changeability in the snacking pattern of adolescents**" are presented under the following headings

4.1 Baseline survey of the selected school students

4.1.1 Demographic profile of the selected students

4.1.2 Meal consumption pattern of selected school children

4.1.3 Snacking pattern among selected school children

4.1.4 Awareness on millets

4.1.5 Taste preference for new snack

4.2 Mean sensory scores of formulated nutri dense pack

4.2.1 Multigrain cookies

4.2.2 RTE crispy snacks

4.3 Nutrient content of the formulated nutri dense pack

4.3.1 Multigrain cookies

4.3.2 RTE crispy snacks

4.4 Storage stability of the formulated nutri dense pack

4.4.1 Mean sensory scores of multigrain cookies and RTE snack on storage

4.4.2 Microbial load of the formulated nutri dense pack on storage

4.5 Effect of nutri dense pack on nutritional profile of the selected school students

4.5.1 Anthropometric measurements of study participants

4.5.2 Biochemical indices of study participants

4.5.3 Academic performance of the study participants

4.5.4 IQ and Aptitude test scores of study participants

4.6 Nutritional knowledge of the selected participants

4.1 Baseline survey of the selected school students

4.1.1 Demographic profile of the selected students

Demographic profile of the selected participants were consolidated and tabulated in Table I.

Table I

Demographic profile of the selected participants

Demographic profile	Group	Percentage	Number
Sex	Male	52	513
	Female	48	471
Age (yrs)	15	3	29
	16	31	306
	17	33	324
	18	29	286
	19	4	38
Class	10	34	335
	11	33	328
	12	33	321
Type of family	Nuclear	72	708
	Joint	28	276
Fathers occupation	Government	23	227
	Private	61	600
	Business	12	118
	Any other	4	39
Mothers occupation	Government	18	177

	Private	45	443
	Self Help Group	24	236
	Homemaker	13	128
Monthly income	Low	26	256
	Medium	53	522
	High	21	206

About 1000 students were selected for the study from three schools at Coimbatore. Of which, only 984 students were willingly participated and provided consent to be participants for survey. Hence, 16 students were rejected from the study due to incomplete forms. Among 984 students, 52 percent (513) were boys and 48 percent (471) were girls. Higher percentage of the students (33 per cent) was in the age of 17 years, 31 percent was in 16 percent and 29 percent were in 18 yrs since they were in higher secondary schools. Equal percentage of the students was in all the 10, 11 and 12 grades. Almost 72 percent of the students were from nuclear family remaining (28 percent) followed joint family system. 61 and 45 percent of the students' fathers' and mothers' occupation was in private concerns respectively. 24 percent of the mothers were self help group members. 53 percent of the school students' were from middle income group. 26 and 21 percent were in low and high income group respectively.

4.1.2 Meal consumption pattern of selected school children

Meal consumption pattern of the selected school children were collected using the drafted questionnaire, consolidated and presented in figure 1 and 2.

Fig 1
Meal skipping pattern

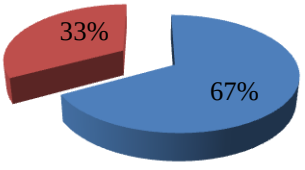
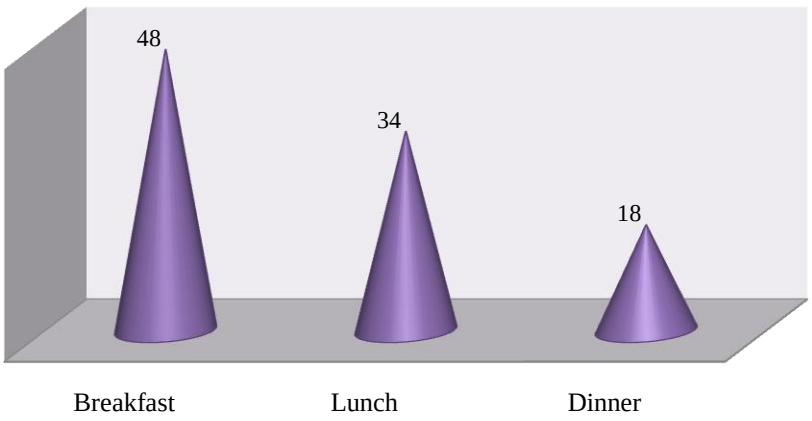


Fig 2
Type of meal skipped by selected school children



Among the participants, 67 per cent of the students skipped their meals regularly. Around 48 percent and 34 percent of students skipped their breakfast and lunch respectively. Only 18 percent of the students missed their dinner rarely. On a daily basis, more adolescents skipped breakfast than skipped lunch or dinner (Figure 3).

4.1.3 Snacking pattern among selected school children

The prevalence of snacking (defined as *the consumption of foods and drinks between meals including milk drinks, regular soft drinks, sports drinks and energy drinks*) among adolescents and children varies widely across the world. Snacking is also commonly associated with undesirable health outcomes and dietary patterns. Since children and adolescents select snacks based on taste over nutrition, they more often choose salty, crunchy foods as snacks over healthier alternatives. 46 percent of the school students had snacks outside home moderately (3 or 4 days per week) and 37 percent had very often (5 to 7 days per week). Most of the school students (56 percent) had snacks 2 to 3 times a day. Snacking after school was the most common context with 46 percent of school students indicating they snacked during this time on most days or every day. Adolescents also snacked frequently while watching TV and while hanging out with friends. Snacking while doing homework or working, on the run, or on the way to or from school were less common. Adolescents were least likely to snack in the middle of the night (7 percent) with less than 26 percent of students reporting that they often snacked in the morning break.

Findings show that most respondents obtained their snacks from grocery shops or supermarket and fast food restaurant. Remaining took snacks at home and school canteen.

The present study also shows that spending power of majority of participants was (59 percent) only Rs. 25 or less for snacks, 21 percent spent Rs.25 – 50, 20 percent spent more than Rs. 50/-. The expenses for snacks among the adolescents were very little as they were depended on their parents to buy snacks. Snacking pattern of the selected school children were tabulated in Table II.

Foods that were most frequently consumed as snacks by respondents, which were consumed everyday on a week, included chat items, bakery items and fried items while beverages that were most frequently consumed between meals included carbonated drinks and fruit juices. Students rarely prefer sweets or savouries compared to chat and bakery items. They also hesitate to include fresh fruits however they would like to include flavoured or preserved juices.

Table II

Snacking pattern among selected school children

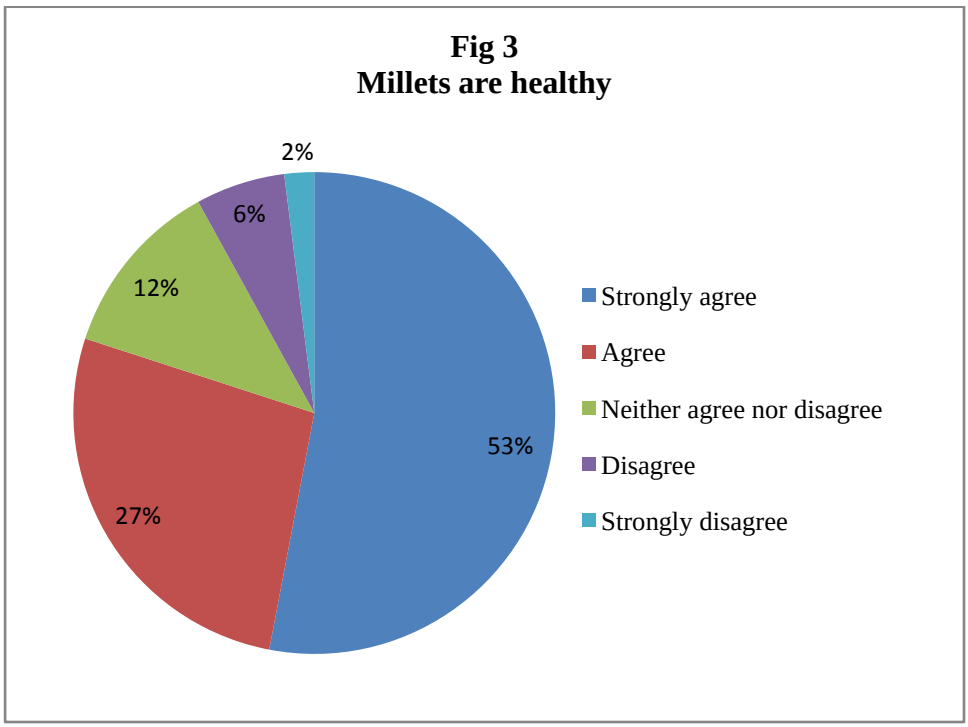
Snacking pattern	Criteria	Number of participants	Percentage
Frequency of snacking outside	Rarely (1 or 2 days)	167	17
	Moderately (3 or 4 days)	453	46
	Very often (5 or 7 days)	364	37
Frequency of snacking in a day	Rarely (1 – 2 times)	207	21
	Moderately (2 – 3 times)	551	56
	Often (3 – 4 times)	147	15
	Very often (more than 5 time)	79	8
Time of snacking	Morning	256	26

	Afternoon	207	21
	Evening	453	46
	Night	68	7
Amount spent on snacks per day	Rs. 0 – 25	580	59
	Rs. 25 – 50	207	21
	Rs. 50 – 100	108	11
	Above Rs. 100	89	9

4.1.4 Awareness on millets

Information on millets as healthy foods were obtained from selected school students and given in figure 3 More than half of the participants (53 percent) strongly agree that millets are healthy kind of food. 12 percent and very few disagreed that millets are healthy foods and they were not aware of different kinds of millets available in market.

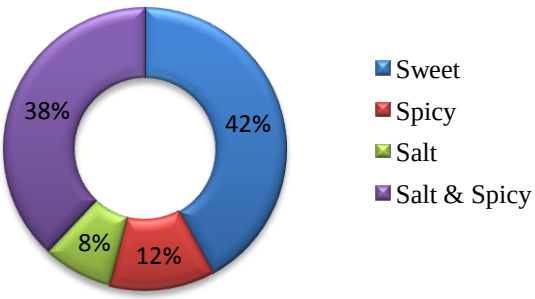
Fig 3
Millets are healthy



4.1.5 Taste preference for new snack

Students were interviewed to identify their taste preference for product development. Data of the respondents were consolidated and given in figure 4.

Fig 4
Taste preference for snacks



About 42 percent of the selected students preferred their snacks in sweet taste.38 percent of them were ready to accept salt and spicy snacks. However minimum percentage of 8 percent preferred the snacks in plain salt taste. Students were also enquired about any allergies on wheat, soya or milk. There was no such evidence for allergic reactions with common ingredients; it was also reconfirmed with the parents. Based on the preferences, a sweet cookie and RTE crispy snack was formulated using multigrain keeping millets as main ingredients.

4.2 Mean sensory scores of formulated nutri dense pack

4.2.1 Mean sensory scores of multigrain cookies

Snack foods are designed to be less perishable, more durable and more appealing than natural foods. The acceptance of snacks is critical because of the specific quality attributes that attract people. The various sensory quality attributes of snack foods are appearance, texture, taste, colour and flavour. The mean sensory scores of the formulated multigrain cookies were tabulated in Table III.

Table III

Mean sensory scores of multigrain cookies

Variation	Colour and	Texture	Flavour	Taste	Overall

	Appearance				acceptability
Standard	8.1 ± 1.20	8.1 ± 1.11	7.5 ± 0.86	7.1 ± 0.18	8.6 ± 0.26
Variation I	7.9 ± 1.12	7.2 ± 1.59	8.2 ± 1.28	8.1 ± 2.01	8.3 ± 1.19
Variation II	7.8 ± 0.89	7.9 ± 0.49	8.4 ± 0.63	8.3 ± 0.99	8.0 ± 0.63
Variation III	7.1 ± 1.43	7.8 ± 0.74	7.3 ± 0.66	7.9 ± 0.12	7.7 ± 0.33
Variation IV	7.9 ± 0.87	7.4 ± 0.97	7.8 ± 0.94	8.3 ± 0.78	8.5 ± 0.96

Standard – 100 per cent Refined Wheat flour
Variation I (SF) – Sorghum flour
Variation II (PF) – Pearl millet flour
Variation III (FF) – Finger millet flour
Variation IV (SPF) – Sorghum : Pearl millet : finger millet

The mean sensory scores of the multigrain cookies revealed that the formulated cookies were on par accepted with that of control cookies. The colour and appearance of sorghum flour and multigrain cookies were highly acceptable with a score of 7.9 on 9 point hedonic scale. However there is no significant difference between the control cookies and multigrain cookies. Colour of the finger millet cookies (Variation III) was 7.1 which was due to darker brownish colour. Texture of the cookies was not altered among the multigrain cookies but it was higher for the control sample due to lack of gluten in millet flour in their variations. Yet scores of texture for multigrain cookies ranged from 7.2 to 7.9.

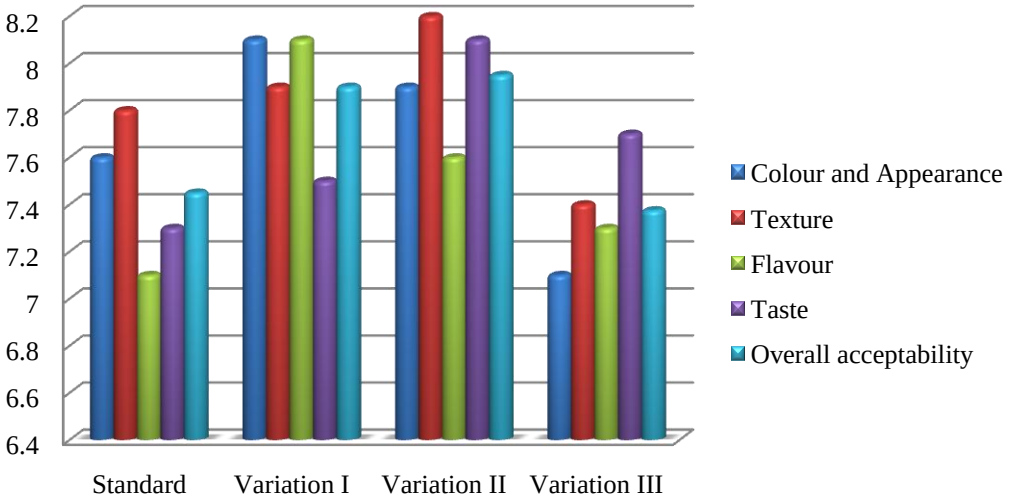
Mean flavour scores indicates that variation II (8.4) had the highest score due to the flavour components of pearl millet flour followed by sorghum flour (8.1) and multigrain cookie (7.8). It is interesting to note that the sensory scores points out that the multigrain cookies were highly acceptable compared to plain wheat flour cookies. Taste of the multigrain cookies were 7.9 to 8.3 whereas it is 7.1 for standard cookies made of wheat flour. On the whole overall acceptability of the multigrain cookies was highly acceptable with a score of 8.5 which is equal to the standard cookies (8.6). Variation IV with all the millet flour had the highest score of 8.5 followed by sorghum flour (8.3), Pearl millet flour (8.0) and then finger millet flour (7.7). Thus the mean sensory scores of the multigrain cookies confirm the acceptability of the cookies among the semi-trained panel members.

4.2.2 Mean sensory scores of RTE crispy snack

Millet and pulse based multigrain flour was extruded and flavoured with oil and spices. The RTE crispy snack was evaluated for sensory acceptability among the taste panel

members. The mean sensory scores of the formulated RTE crispy snack were tabulated in figure 5.

Fig 5
Mean sensory scores of RTE crispy snack



Control = 50% Rice and 50% maize
Variation I = 90 % Cereals: 10% Pulses
Variation II = 80 % Cereals: 20% Pulses
Variation III = 70 % Cereals: 30% Pulses

Mean sensory scores of the RTE crispy snack indicates that colour and appearance of the variation I (8.1) and Variation II (7.9) was highly acceptable compared to control (7.6). Colour of the millet and pulses flour may be the factor to increase the scores for samples. Texture of the RTE snack was altered as the proportion of pulse flour increases. Variation II with 20 percent pulse flour had the highest sensory acceptability as pulse flour increased to 30 percent the texture was little harder. Among sensory attributes, texture is one of the most important one and it is particularly true for RTE snack foods (Bourne 2002).

Flavour of the 10 percent pulse flour sample was higher compared to control and other samples. Inclusion of the pulse flour could be the main reason for the pronounced of flavour. Variation II (8.1) had highest sensory score for taste followed by variation III. Taste of the control was less compared to variations due to lack of millet and pulse flour.

Overall acceptability of the RTE crispy snack was found to be higher for Variation I and II with a score of 7.9 and 7.95 respectively. The results revealed that the acceptability of the millet and pulse flour incorporated snacks was high compared to control.

4.3 Nutrient content of the formulated nutri dense pack

4.3.1 Multigrain cookies

The proximate composition of formulated multigrain cookies was analyzed and tabulated in Table IV.

Table IV

Nutrient content of formulated multigrain cookies (per 100 g)

Proximate composition	Control	Variation I	Variation II	Variation III	Variation IV
Moisture (%)	7.5 ± 0.21	7.4 ± 0.42	7.3 ± 0.01	7.3 ± 0.1	7.4 ± 0.02
Ash (%)	1.5 ± 0.15	1.9 ± 0.09	2.1 ± 0.31	2.2 ± 0.04	2.4 ± 0.17
Protein (g)	11.1 ± 0.16	12.3 ± 0.22	12.5 ± 0.81	13.1 ± 1.02	13.7 ± 1.0
Fat (g)	21.1 ± 0.51	20.8 ± 0.43	20.9 ± 0.33	21.3 ± 0.91	21.1 ± 0.72
Carbohydrate (g)	65.78 ± 0.81	66.24 ± 0.24	66.54 ± 1.01	65.73 ± 0.95	65.12 ± 1.12
Energy (Kcal)	521 ± 2.31	509 ± 5.15	523 ± 1.24	518 ± 6.12	510 ± 5.14
Fibre (g)	0.5 ± 0.20	1.6 ± 1.30	2.2 ± 0.41	2.5 ± 0.92	2.9 ± 1.23
Iron (mg)	1.9 ± 0.43	2.6 ± 0.02	2.5 ± 0.31	2.7 ± 0.11	2.6 ± 0.29
Calcium (mg)	17 ± 0.21	23 ± 1.2	23 ± 0.9	29 ± 1.01	28 ± 1.2

The formulated composite flour cookies contain moisture content in the range of 7.3 ± 0.01 to 7.5 ± 0.21 per cent. The moisture content of composite flour cookies was lower than the FSSAI (8 per cent) value. There is no significant difference ($p>0.05$) in the moisture content of cookies. Observation noted by Kiin and Eke (2013) showed that moisture content of cookies was in the range of 6.54 to 6.44 per cent for plantain flour incorporated cookies. Ash content of the cookies ranged from 1.5 ± 0.15 to 2.4 ± 0.17 per cent which indicates that as the composition of multigrain flour changes there is increase in ash content of the cookies.

Protein content ranged from 12.3 ± 0.22 to 13.7 ± 1.0 per cent for the multigrain cookies which was higher than the control of 11.1 ± 0.16 percent which may be due to the

addition of millet and pulse flour. Fat content of composite flour cookies ranged between 20.8 ± 0.43 to 21.3 ± 0.91 per cent for composite flour cookies. There is no significant difference between the multigrain cookie and control cookie in the fat content. Noor (2012) found that mung bean cookies had about 23.92 per cent and chickpea cookies had about 24.36 per cent fat.

Fiber content of standard cookies was 0.5 ± 0.20 per cent and that of composite flour cookies contain fiber content of 1.6 ± 1.30 to 2.9 ± 1.23 per cent. Okpala and Okoli (2011) observed that fiber content ranged from 2.17 to 2.43 per cent with cookies made with cocoyam flour and sorghum flour. The carbohydrate content of composite flour cookies was in between 65.12 ± 1.12 to 66.54 ± 1.01 per cent. Similar results was reported by Olaoye *et al* (2006) who noticed that while increasing the level of millet flour the carbohydrate content of cookies decreased (60.58 to 52.25 per cent). The energy value of composite flour cookies ranged from 509 ± 5.15 to 523 ± 1.23 kcal/100g which could be due to low energy and high fibre content of millet flour. Mazaher (2009) developed cookies by incorporating millet flour which had energy value of 391.76 to 398 kcal/100g. Micronutrients, minerals namely iron and calcium were estimated for the multigrain cookies and found to be in the range of 1.9 to 2.7 mg and 17 to 29 mg respectively.

4.3.2 RTE crispy snacks

The proximate composition of RTE crispy snacks was analysed and tabulated in Table V. The moisture content of the extrudates varied from 2.14 ± 0.23 to 2.32 ± 0.18 percent which is the desirable for extruded snacks to maintain the crispiness. Similar levels of moisture values of 0.7 to 2.7 g were reported for RTE extrudates made from sorghum and rice (Lakshmi Devi et al. 2012). Ash content was very high (6.09 ± 0.18 g) in the control sample when compared to the experimental samples. The ash content of experimental samples, ranged from 1.54±0.26 to 3.32±0.28 g.

The protein content of the control and the experimental samples were in the range 10.58 ± 0.18 to 13.98 ± 0.51 g. The fat values were in a range of 8.6 ± 0.23 to 8.8 ± 0.32 g. The fat content in the RTE extrudates was due to the spicing (added oil & spices) given to all the extrudates to improve the palatability rather than fat content of the raw ingredients.

Table V

Nutrient content of RTE crispy snacks (per 100 g)

Proximate composition	Control	Variation I	Variation II	Variation III
Moisture (%)	2.32 ± 0.18	2.31 ± 0.08	2.14 ± 0.23	2.21 ± 0.11
Ash (%)	1.54 ± 0.20	2.6 ± 0.41	2.9 ± 0.18	3.22 ± 0.34
Protein (g)	10.58 ± 0.18	12.11 ± 0.15	13.12 ± 0.20	13.98 ± 0.51
Fat (g)	8.6 ± 0.23	8.7 ± 0.19	8.6 ± 0.18	8.8 ± 0.32
Carbohydrate (g)	72.36 ± 0.38	72.41 ± 0.44	71.80 ± 0.51	71.61 ± 0.41
Energy (Kcal)	431± 2.60	429 ± 3.14	433 ± 3.57	434 ± 4.11
Fibre (g)	0.72 ± 0.08	0.84 ± 0.06	0.95 ± 0.08	1.25 ± 0.05

The crude fiber content unlike ash was least in the control sample (0.72 ± 0.06 g) while in the experimental extrudates, the values ranged from 0.84 ± 0.06 to 1.25 ± 0.05 g. The fiber content in extruded snacks made with rice and chickpea also showed a similar value of 1.38 g (Bhattacharyya et al. 1997). Carbohydrate content of the formulated RTE snack ranged from 71.61 ± 0.41 to 72.41 ± 0.44 g per 100 g. The energy value of all the products was almost similar ranging from 429 ± 2.60 to 434 ± 4.11 kcal.

4.4 Storage stability of the formulated nutri dense pack

4.4.1 Mean sensory scores of multigrain cookies and RTE crispy snack on storage

Thirty panellists took part in the sensory analysis on 0th day and 60th day (after storage). They indicated liking of colour & appearance, texture, taste, flavour, mouth feel and overall acceptability on a nine-point scale.

Fig 6
Mean seosory scores of multigrain cookies on storage

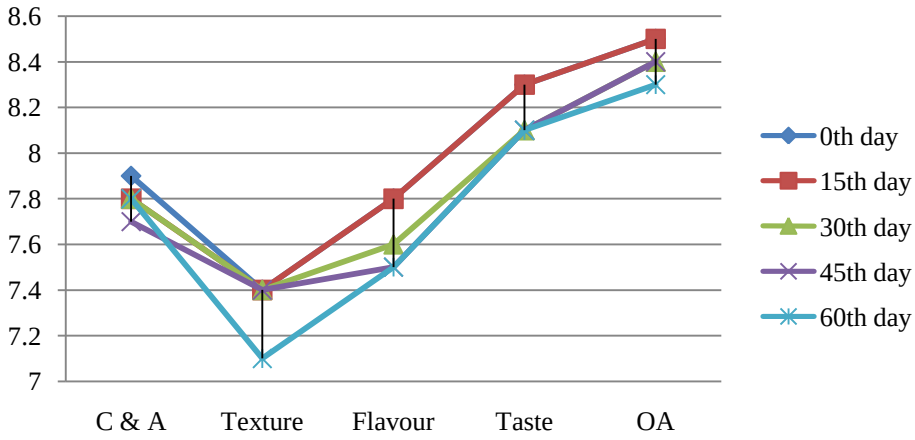


Fig 7
Mean sensory scores of RTE snacks on storage

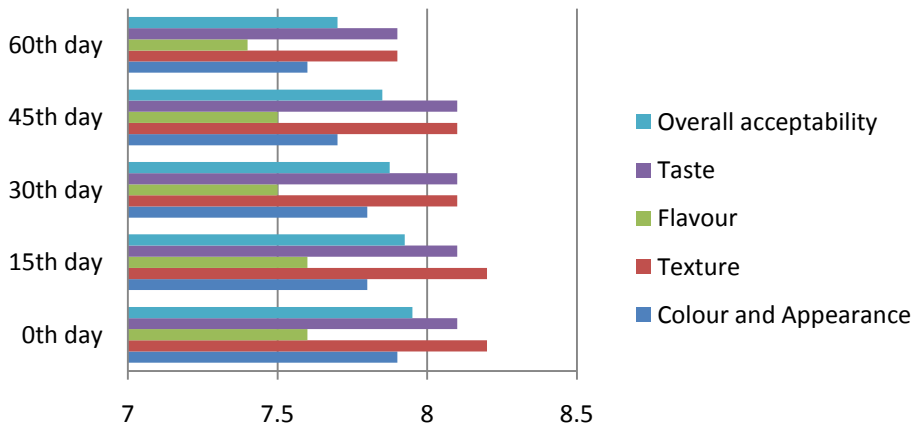


Figure 6 and 7 shows the results of sensory evaluation of the selected product on storage for two months. Among 5 types of cookies highly acceptable multigrain cookie (Variation IV) and four types of RTE snacks, 20 percent pulse incorporated RTE crispy snack (Variation II) were selected for further storage stability and intervention study. Mean sensory scores of the selected multigrain cookies on storage were tested for 60 days every 15 days interval. On storage, the mean sensory scores of cookies and RTE snacks do not have significant difference even after 60 days of storage. Colour and appearance of the cookies and crispy snack does not alter to great extent. Texture and flavour of both the products had slight reduction on 60th day. However, there is no change in taste and overall acceptability. The loss in texture and flavour can be rectified with an improved packaging material.

4.4.2 Microbial load of the formulated nutri dense pack on storage

Among 5 types of cookies highly acceptable multigrain cookie (Variation IV) and four types of RTE snacks, 20 percent pulse incorporated RTE crispy snack (Variation II) were selected for further storage stability and intervention study. Microbial load of the nutri dense pack was analysed by total plate count method on every 30^{th} day and the results were tabulated in Table VI. The results showed that there was no significant increase in microbial load on storage which may be due to low moisture content of the developed pack and proper storage.

Table VI

Microbial load of the nutri dense pack

S.No	Period of study	Total plate count (cfu*/g)	
		Multigrain cookies	RTE crispy snack
1	0^{th} day	3×10^3	2×10^3
2	30^{th} day	4×10^3	2×10^3
	60^{th} day	6×10^3	3×10^3

*colony forming unit

The selected multigrain cookies (Variation IV) and RTE crispy snack (Variation II) were packed in airtight polythene covers and kept at room temperature. The result showed that there was less microbial count at zero day. The bacterial count on zero day was ranged from 3×10^3 to 6×10^3 cfu/g for multigrain cookies and 2×10^3 to 3×10^3 for RTE crispy snacks. The specified limit for the colony forming units in cookies is 7×10^3 cfu/g. Thus it was observed that the microbial load was within the specified limit. It keeps its freshness for more than one month when it was kept in an air tight package.

Phase IV Intervention study

4.5 Effect of supplementation on nutritional and academic performance

Totally 100 school students were selected from the baseline survey. Of which, 50 students were grouped as control and 50 were grouped as experimental group. Control group

participants were provided with plain cookies and mixture. Experimental group participants were supplemented with multigrain cookies and RTE crispy snack for a period of 90 days.

4.5.1 Anthropometric measurements of the study participants

Height and weight measurements of the weavers

The mean height and weight of the selected 100 school children were measured and presented in Table VI.

Table – VI

Mean Height and Weight of the selected study participants

Height / Weight	Groups	Initial (Kg/m^2)	Final (Kg/m^2)	Percent difference	t value
		Height (cm)			
Boys	Control	164.88 ± 1.25	164.13 ± 1.42	0.75	1.213*
	Experimental	165.29 ± 2.58	166.89 ± 2.89	1.60	6.129*
Girls	Control	151.83 ± 0.42	152.03 ± 1.38	0.20	2.017*
	Experimental	153.75 ± 1.65	154.82 ± 0.76	1.07	5.246*
		Weight (kg)			
Boys	Control	52.52 ± 3.55	52.93 ± 5.46	0.41	-0.525^{NS}
	Experimental	53.17 ± 3.28	54.89 ± 2.29	1.72	7.149*
Girls	Control	45.03 ± 2.42	44.89 ± 1.25	0.86	0.068^{NS}
	Experimental	44.96 ± 1.34	48.19 ± 2.01	2.23	8.216*

Height indicates long term nutritional status. In the present study the selected students were found to be in normal status. Initially, mean height of the selected students was recorded to be 164.88 ± 1.25 cm and 151.83 ± 0.42 cm for control group boys and girls respectively. After 90 days of study period, there was significant difference in both the groups for boys and girls which may be due to the adolescent stage. There was only minimum difference in the mean values ranging from 0.75 for boys and 0.20 for girls in control group whereas for experimental group it was 1.60 (boys) and 1.07(girls)

The mean weight of the selected school students was found to be 52.52 kg for boys and 45.03 for girls in pre intervention period. Most of them were found to be slightly

underweight in the present study which might be due to inadequate dietary intake. After the intervention period of 90 days, there was a slight increase in weight for both boys (1.72 kg) and girls (2.23 kg) which is a welcome observation. The overall anthropometric measurements indicated that most of the boys and girls were found to be underweight due to lack of nutrients intake which might lead to health problems in the long run. Hence, an healthy kind of snacks could definelty help them in providing essential nutrients to a great extent.

Body Mass Index (BMI)

Table VII present the details regarding Body Mass Index of the selected school children calculated using the height and weight data.

Table VII

Body Mass Index of the selected school children

BMI	Groups	Initial (Kg/m^2)	Final (Kg/m^2)	Percent difference	t value
Boys	Control	19.30 ± 1.55	19.20 ± 1.46	0.10	-0.510^{NS}
	Experimental	19.50 ± 2.58	20.10 ± 2.29	0.60	7.149*
Girls	Control	19.50 ± 1.42	19.40 ± 1.38	0.10	0.068^{NS}
	Experimental	19.00 ± 1.65	20.10 ± 1.76	1.10	8.216*

Both girls and boys had BMI values within normal range during the pre and post period of study. On the post intervention study, it was observed that control group students there was decrease in BMI values which may lead to underweight category on long run. However, experimental group students had an increase in BMI value from 19.5 to 20.10 in boys and 19.00 to 20.10 in girls. The overall picture of the BMI values of the selected school students indicated that students were in the normal category whereas a majority of the control group respondents were in stage of moving to underweight category.

4.5.2 Biochemical indices of the study participants

The results of the present study revealed that the mean heamoglobin and serum protein level of the experimental group was higher than the control group after the supplementation of the nutri dense pack for 90 days. The changes in the haemoglobin, serum

protein level and lipi profile of study participants before and after the supplementation was assessed and tabulated in Table VIII.

Table VIII

Changes in mean haemoglobin, protein and lipid profile of the study participants

Biochemical indices	Groups	Initial	Final	Difference	p Value
Mean haemoglobin	Control group	9.81 ± 0.23	9.73 ± 0.19	- 0.08	0.042^{NS}
	Experimental group	9.98 ± 0.38	11.24 ± 0.78	+ 1.26	1.280^{S}
Serum protein	Control group	6.58 ± 0.74	6.46 ± 0.93	- 0.12	0.064^{NS}
	Experimental group	6.49 ± 0.41	7.61 ± 0.52	+ 1.12	2.981^{S}
Triglycerides	Control group	96.31 ± 21.56	98.56 ± 20.57	+ 2.25	0.18^{NS}
	Experimental group	95.83 ± 24.45	89.66 ± 24.22	- 6.17	1.29^{S}
LDL	Control group	68.92 ± 15.24	69.35 ± 11.95	+ 0.43	0.22^{NS}
	Experimental group	69.52 ± 16.39	67.10 ± 13.93	- 2.42	1.97^{S}
VLDL	Control group	19.26 ± 3.28	20.93 ± 3.09	+ 1.67	0.24^{NS}
	Experimental group	19.57 ± 4.32	17.64 ± 4.16	- 1.93	2.01^{S}
HDL	Control group	28.98 ± 4.67	27.12 ± 3.97	- 1.86	0.15^{NS}
	Experimental group	29.97 ± 5.95	32.29 ± 5.56	+ 2.32	1.67^{S}
Total Cholesterol	Control group	120.18 ± 21.84	125.64 ± 21.90	+ 5.46	0.98^{NS}
	Experimental group	118.83 ± 23.97	110.84 ± 19.42	- 7.99	2.04^{S}

^{S} – Significant ^{NS} – Not significant

From the table VIII, it was observed that there was a significant increase in the mean haemoglobin level of the experimental group, from 0^{th} day to the end of the study (90^{th} day). The mean was 9.81 ± 0.23 in the 0th day which gradually decreased to 9.73 ± 0.19 in the end

of the study (90th day). In the Experimental Group, the mean haemoglobin level was found to be 9.98 ± 0.38 in the 0th day and 11.24 ± 0.78 in the 90th day. When the initial value was compared with 90th day's value, the results indicated that the haemoglobin level of the subjects of Control Group decreased slightly where there is a chance of decreasing further and lead to severe anaemic condition. However, heamoglobin value of the experimental group had a significant increased by 1.26 after 90 days. Owino et al (2007) have reported that supplementation of energy dense foods have improved the haemoglobin concentration. In another study supplementation of fortified beverage for 6 months has significantly improved the hematologic and anthropometric measurements and significantly lowered the overall prevalence of anemia deficiency among the children (Sivakumar et al 2006).

The mean serum protein levels of the adolescent school children at pre and post intervention were in the normal category with serum protein levels greater than 6.0 g% (Table VI). The serum protein status of the adolescence was found to be adequate. On intervention with nutri dense snack, it was observed that the control group had a decrease in protein values which is not advisable. It was found that the mean serum protein values of study participants before supplementation (0 day) was 6.58 ± 0.74 g in control subjects, while in experimental subjects it was 6.49 ± 0.41 g. After 90 days of supplementation, the difference of serum protein level of control subjects (6.46 ± 0.93) was found to be 0.12 and that experimental group (7.61 ± 0.52) was 1.12. The increase in mean serum protein level after supplementation indicates that intervention had made slight improvement in the protein status.

There was a significant reduction in total cholesterol, LDL, VLDL, triglycerides level of experimental group after supplementation whereas in control group a slight increase in the values was noted. HDL level of experimental group was initially 29.97 ± 5.95 but after intervention it increased to 32.29 ± 5.56 which was reduced in control group. Total cholesterol level of control and experimental group was 120.18 ± 21.84 and 118.83 ± 23.97 initially, after three months the values were 125.64 ± 21.90 and 110.84 ± 19.42 respectively which denotes the healthy improvement in lipid profile of the supplemented group students.

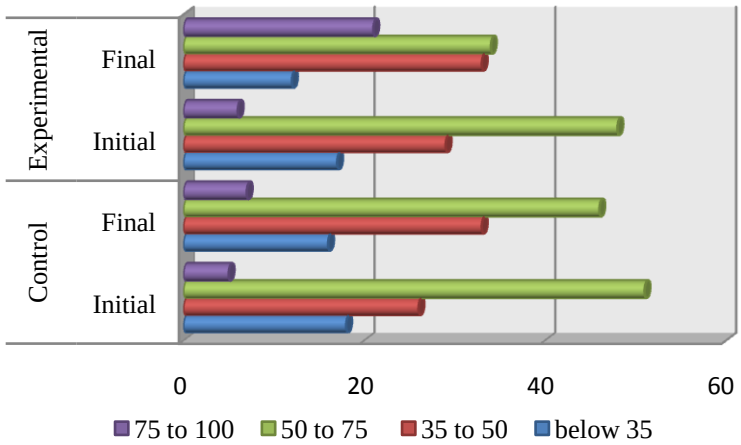
Among the 100 adolescent girls, who were in the age group of 16 - 19 years were selected for the supplementation with their consent. The study with respect to haemoglobin and serum protein level showed an increase in haemoglobin level by 1.26 g/dL and in protein by 1.12 g percent after supplementation of 2 multigrain cookies (150 g) and 25 g of RTE

Crispy snack in daily diet. Total cholesterol, LDL, VLDL and triglycerides level reduced and HDL level increased from the initial values.

4.5.3 Academic performance of study participants in major subjects

Children who are undernourished appeared to have increased absence from school and diminished attention, as well as encountering more health problems in comparison with well-nourished children, all of which would indeed affect performance at school (Santanu et al, 2013). The academic performance of students was assessed via the grades they scored in the model exams. As the students were studying a combination of different subjects, academic performance was assessed according to the average grade of all the subjects studied. Figure 8 presents the details regarding the academic scores of the selected students in the study groups.

Fig 8
Academic scores of the study participants



As the academic performance of the study subjects was assessed via the grades they scored on the final exams, they were categorised into four grades – A (above 75), B (50 – 75), C (35 – 50) and D (below 35). The grades scored by the students in the control group were as follows: 51 percent of the students scored C, 26 percent scored B, 18 percent scored D and 5 percent scored Grade A. Similar results were found in experimental group in the initial period of the supplementation study but on 90th day, second model exam there was an increase in marks obtained by students who took nutri dense pack supplementation. 6 percent of grade A students in initial period was increased to 21 percent after 90 days of supplementation and there is a decrease in grade D. These results support the outcomes of a study that was conducted in South Korea to examine the effect of breakfast on the academic

performance of both male and female adolescents from the 7th to the 12th classes. The researchers in the South Korea study were able to identify a strong link between breakfast skipping and obesity. Obesity is related to reduction in cognition and memory due to its effect on the structure of the brain. Therefore, skipping breakfast was found to be a cause for obesity, which is indeed related to lower academic performance (So, 2013). The results of the current study also in accordance with Norwegian study, which investigated the effect of a regular meal pattern on the academic performance of students. It found that the regular consumption of breakfast as well as increased intake of healthy foods are associated with increased learning outcomes and high school achievements, particularly in female students (Stea and Torstveit, 2014).

4.5.4 IQ and Aptitute scores of study participants

The IQ and aptitude scores were consolidated and number of respondents under each category in tabulated in Table IX.

Table IX

IQ and Aptitude scores of the study participants

		Control (N = 50)			Experimental (N = 50)		
		Verbal	Spatial	Numerical	Verbal	Spatial	Numerical
Expert (11 - 12)	Initial	5	4	3	4	5	3
	Final	6	4	2	6	7	4
High average (10)	Initial	10	8	7	8	7	6
	Final	9	7	5	17	14	11
Middle average (8 - 9)	Initial	11	12	11	10	13	9
	Final	13	7	4	19	20	17
Low average (7)	Initial	19	17	14	16	14	12
	Final	18	20	21	5	6	15
Borderline low (5 - 6)	Initial	3	8	12	8	6	11
	Final	2	10	13	1	2	2
Low (3 - 4)	Initial	2	1	3	4	5	9
	Final	2	2	5	2	1	1

Considering the three types of aptitude namely verbal, spatial and numerical aptitude, there was a gradual increase in number of participants who shifted from low average and borderline to middle average and low average respectively. Overall, there was a considerable increase in number of students under the category of high average and expert group. In verbal aptitude, 19 students were in the low average and 11 students were in the middle average category initially. At the end of the study period also there was no significant change in those 2 categories. However, after the study period in experimental group, there was an increase in number of students under middle average and high average category. Considering the experimental group spatial aptitude, 5, 7 and 13 students were in expert, high and middle average category initially and improvement was identified among 7, 14 and 20 students respectively.

Similarly in numerical aptitude test, initially 6 and 9 students were in high and middle average category respectively however it increased to 11 and 17 after supplementation whereas in control group there was no significant difference. It is observed that in the supplement group, number of participants in low category was reduced and middle average and high average category got increased. Results indicated an increase in verbal, spatial and numerical aptitude may be observed due to the habit of healthy snacking. Hence, from the above results, it is noted that healthy eating and nutritional status of a school student has definite relationship with his/her IQ and aptitude scores.

4.6 Nutrition education

Nutritional knowledge of selected participants were assessed using the questionnaire before and after nutrition education and presented in Table X.

Table x

Nutritional knowledge of the selected participants

Knowledge on	Knowledge scores		
	Before education	After education	BE Vs AE
Balanced diet and nutrients	11 (22)	45 (90)	-12.15*
Healthy eating	17 (34)	46 (92)	-9.61*
Awareness on millets	13 (26)	48 (96)	-9.00*

BE –Before education, AE – After education *Significant at 1% level

From the table, it is clear that on an average 22 to 34 percent of the school students had knowledge on balanced diet, nutrients, importance of breakfast and millets initially. After nutrition education, majority of the respondents (90 to 96 per cent) gained knowledge on nutrients and the impact of healthy eating. Almost 96 percent of the population understood that millets are good for health. Almost above 90 – 92 percent of them gained appropriate knowledge on effect of healthy snacking, importance of food groups and RDA.

CHAPTER V

SUMMARY AND CONCLUSION

Adolescence is an important period during human lifespan that signals the entrance of individuals into the world of adults (WHO, 1995). Nutritional requirement during adolescence is the highest as compared to other stages across the life span in order to achieve optimal growth and development (NCCFN, 2005). Therefore, nutritional intake during adolescence is important for long-term health promotion and the development of healthy eating behaviour in the future as it may predict the occurrence of obesity and other diet-related chronic diseases later in life (Neumark-Sztainer*et al.*, 2007). The usual perception on snacking is that snack foods are high in fat and sugar and hence harmful and not conducive for healthy eating (Astrup*et al.*, 2006). In general, snacking can be defined as food or drink eaten between main meals (Chaplin and Smith, 2011) and also based on the time criterion (Gregori and Maffeis, 2007). Adolescents tend to select snacks based on taste over nutrition, and they more often choose salty and crunchy foods as snacks over healthier alternatives. Snacking may also be associated with less frequent consumption of meals, which may be detrimental to health since regular meal patterns are associated with greater dietary diversity, healthier food choices and better nutrient intakes. More frequent snack intake is often associated with excess energy intake and non-balanced nutrient intakes, and subsequently causing the increase of overweight and obesity among the adolescents (Nicklas, 2003). Keeping in mind the above facts, a study was undertaken to formulate nutri dense snack based on millets and find the efficacy of the pack on nutritional and academic performance among school children.

Survey on snacking pattern was conducted among selected school children to assess the demographic profile, meal pattern, awareness on millets and preference towards snacks using structured questionnaire. Further, a millet based nutri dense pack was developed with multigrain cookies and RTE crispy snack. Sensory acceptability, nutritional profile and storage stability of the pack was assessed. After, the developed pack was supplemented among the school children for 90 days. They were grouped as control and experimental. Control group was provided with plain cookies and mixture available in market and experimental group was supplemented with 150 g of multigrain cookies and 25 g of RTE crispy snack.

Findings

Phase I – Baseline survey

- Among 984 students, 52 percent (513) were boys and 48 percent (471) were girls.
- Almost 72 percent of the students were from nuclear family remaining (28 percent) followed joint family system.
- 53 percent of the school students' were from middle income group.
- Among the participants, 67 per cent of the students skipped their meals regularly. Around 48 percent and 34 percent of students skipped their breakfast and lunch respectively.
- Most respondents (46 percent) were reported that they took afternoon snack, which is between lunch and dinner time.
- 42 percent of the selected students preferred their snacks in sweet taste.38 percent of them were ready to accept salt and spicy snacks.

Phase II – Development of nutri dense pack

- Variation IV with all the millet flour had the highest score of 8.5 followed by sorghum flour (8.3), Pearl millet flour (8.0) and then finger millet flour (7.7).
- Overall acceptability of the RTE crispy snack was found to be higher for Variation I and II with a score of 7.9 and 7.95 respectively
- Protein content ranged from 12.3 ± 0.22 to 13.7 ± 1.0 per cent for the multigrain cookies which was higher than the control of 11.1 ± 0.16 percent which may be due to the addition of millet and pulse flour.
- The moisture content of the extrudates varied from 2.14 ± 0.23 to 2.32 ± 0.18 percent which is the desirable for extruded snacks to maintain the crispiness.
- The energy value of all the RTE crispy snacks was almost similar ranging from 400.08±2.60 to 433.24±3.89 kcal.
- Sensory scores and microbial load of the nutri dense pack indicated that it can be stored for 2 months without any deterioration by microbes. It is also highly acceptable after two months storage in all its sensory characteristics.

Phase III – Intervention study

- Anthropometric measurements did not show a clear picture except for a slight increase in weight among experimental group students. Since they were still in a growth stage.

- Biochemical indices showed that there is a significant difference in experimental group than the control group. Haemoglobin level of the study participants in experimental group had a an increase of 1.26 g /dl on an average.
- After 90 days of supplementation, the difference of serum protein level of control subjects was found to be 0.12 and that experimental group was 1.12 g/dl.
- There was a significant reduction in total cholesterol, LDL, VLDL, triglycerides level of experimental group after supplementation whereas in control group a slight increase in the values was noted.
- 6 percent of grade A students in initial period was increased to 21 percent after 90 days of supplementation and there is a decrease in grade D.
- There was a gradual increase in number of participants who shifted from low average and borderline to middle average and low average. Overall, there was a considerable increase in number of students under the category of high average and expert group.

Phase IV – Nutrition education

- On an average 22 to 34 percent of the school students had knowledge on balanced diet, nutrients, importance of breakfast and millets.
- After nutrition education, majority of the respondents (90 to 96 per cent) gained knowledge on nutrients and the impact of healthy eating.
- They were also familiar with choosing healthy snacks after nutrition education.

Conclusion

Increasing snack intake is associated with higher energy intake, besides the more frequent snack intake, the more carbohydrate intake from snacks as compared to protein and fat intake. Hence, school-based delivery in the form of easily distributed nutri dense pack with high protein along with required carbohydrate is essential. Based on the results obtained after intervention, it is evident that the developed nutri dense pack had a significant impact on nutritional, biochemical, academic and IQ and aptitude performance. Hence, school-based interventions of this nature may have considerable advantages over community. Providing energy and nutrients that help optimize children's learning in the classroom and their later capabilities contributes to the national economy.

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