EFFECT OF AMARANTH ON THE HEALTH AND NUTRITIONAL PROFILE OF ADOLESCENTS

By

SUMAN. K. T.

THESIS

Submitted in partial fulfillment of the requirement for the degree of

Master of Science in Home Science

(FOOD SCIENCE & NUTRITION)

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF HOME SCIENCE

COLLEGE OF HORTICULTURE

VELLANIKKARA, THRISSUR - 680 656

Kerala, India

2000

DECLARATION

I hereby declare that this thesis entitled **"Effect of amaranth on the health and nutritional profile of adolescents"** is a bona fide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Vellanikkara
14.7.2000

Suman

SUMAN.K.T.

CERTIFICATE

Certified that this thesis entitled **"Effect of amaranth on the health and nutritional profile of adolescents"** is a record of research work done independently by **Mrs. Suman. K.T.**, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

Omana P

Smt. Omana Pavunny
(Chairperson)
Assistant professor
Department of Home Science
College of Horticulture
Vellanikkara

Vellanikkara
14-7-2000

CERTIFICATE

We, the undersigned members of the Advisory Committee of **Mrs. Suman.K.T.,** a candidate for the degree of **Master of Science in Home Science** with major in **Food Science and Nutrition,** agree that the thesis entitled **"Effect of amaranth on the health and nutritional profile of adolescents"** may be submitted by Mrs. Suman.K.T., in partial fulfillment of the requirement for the degree.

14/7/2000

Smt. Omana Pavunny
(Chairperson, Advisory committee)
Assistant professor
Department of Home Science
College of Horticulture
Vellanikkara

Dr.V.Indira
Associate Professor & Head
Department of Home Science
College of Horticulture
Vellanikkara

Dr.V.Usha
Associate Professor
Department of Home Science
College of Horticulture
Vellanikkara

14/7/2000

Dr.A.Augustin
Associate Professor
(Biochemistry)
AICRP on M&AP
College of Horticulture
Vellanikkara

14/7/2000

EXTERNAL EXAMINER

ACKNOWLEDGEMENT

I wish to express my sincere gratitude to Smt. Omana Pavunny, Assistant Professor, Department of Home Science and the chairperson of my advisory committee, for her valuable suggestions and encouragement during the preparation of the manuscript.

Let me also place on record, my sincere thanks and indebtedness to Smt. Norma Xavier.C., Assistant Professor, Department of Home Science and former chairperson of my advisory committee, for the guidance and encouragement during the course of this investigation.

I am deeply obliged to Dr. V.Indira, Associate Professor and Head, Department of Home Science and member of my advisory committee, for her critical evaluation and valuable suggestions, which was a great help for the successful completion of this work.

I am indeed grateful to Dr. V.Usha, Associate Professor, Department of Home Science and member of my advisory committee, for her timely help and constant encouragement, throughout the course of my study.

I also would like to thank Dr.Augustin, Associate Professor, AICRP on M&AP and member of my advisory committee, for providing the necessary guidelines and critical evaluation of the thesis.

My profound gratitude is due to Dr. E.Soman, Associate Professor and Head, Department of Physical education, for giving the necessary details for conducting the functional performance test.

I sincerely thank Dr.P.V.Prabhakaran, Associate Dean i/c, College of Horticulture and Dr. V.K.G. Unnithan, Associate Professor, Department of Agricultural Statistics, for their valuable suggestions during the statistical interpretation of the data.

The co-operation and help received from the staff and inmates of the institutions mentioned in this study are greatly acknowledged.

Let me thank my friends Maya, Mini and Raji, who have helped me for the completion of my research work. I also thank my seniors and Juniors Sabeena, Saima, Shiji and Vandana for rendering valuable assistance.

The help rendered by Smt. Joicy T. John to carry out the statistical analysis is sincerely acknowledged.

My sincere thanks to Sri.Joy and his family for the neat and prompt typing of the thesis.

The award of Junior Fellowship by Kerala Agricultural University is greatly acknowledged.

The love, affection and support received from my parents, brother, sisters and in-laws was a constant motivation, which will always be remembered by me.

The unerring support and deep concern of my husband for the successful completion of this thesis is affectionately acknowledged.

Above all, I humbly bow before Almighty, whose constant blessing enabled me to complete this endeavour successfully.

Thank you one and all

Suman.K.T.

..... to my family

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

INTRODUCTION

Adolescence is an important phase in the developmental stage of an individual, as it is an entrant population for parenthood and undergoes physical, psychosexual and social changes which needs a careful consideration and compassionate management (Bali, 1990).

Nutrition surveys carried out in India indicate that the incidence of dietary inadequacies are higher during adolescent period. As adolescents are instrumental in shaping the future of the nation, their health and nutritional demands must be considered as a nations' priority, hence optimum nutrition in terms of quality and quantity is essential for their growth and development (Guthrie, 1979).

Among the various nutritional problems prevalent in India a serious consequence following malnutrition is iron deficiency anaemia. Iron deficiency is found to have an effect on cognitive functions, human behaviour, work performance and psychological development (Demaeyer, 1989). It affects the physical work capacity by reducing the availability of oxygen to the tissues which in turn affects the cardiac out put.

During the period of adolescence blood volume and muscle mass increase and this inturn is found to increase the need for haemoglobin formation. If the diet does not contain sufficient absorbable iron and if the adolescent cannot consume adequate amounts of food they become anaemic (Johndhale *et al.*, 1999).

A wide variety of leaves like amaranth, curry leaf, drumstick leaf, fenugreek leaf and mint are used as vegetable in India. Green leafy vegetables are in general, the cheapest sources of protective nutrients like calcium, iron, β carotene, riboflavin, folic acid and ascorbic acid; all of which are essential for growth and maintenance of normal health. Despite their availability all the year

round, leafy vegetables are not consumed in sufficient quantities or frequently enough to prevent the deficiencies of calcium, iron, vitamin A, riboflavin, folic acid and vitamin C.

Among the leafy vegetables amaranth is rich in iron, calcium, β carotene and vitamin C and is a rare example of vegetable where all these essential dietary components are combined in one. The balance diet recommended by ICMR (1984) suggested an inclusion of 50 g and 125 g leafy vegetables daily for adolescent boys and girls (13–15 years), respectively. However average consumption of green leafy vegetables in Kerala is reported to be around 6 g (NNMB, 1996). Rajesh (1991) reported that teenagers often eliminate green leafy vegetables in their diet and thus lack nutrients which are important for their growth and development.

As growth during adolescence contribute significantly to the attainment of final anthropometric measurements of an individual, investigations on adolescent growth pattern, especially among deprived community is important. Hence the present study was undertaken with the objective of assessing the effect of supplementing amaranth in the diets of early adolescents (13–15 years) on their health and nutritional status.

REVIEW OF LITERATURE

In this chapter an attempt has been made to review the literature relevant to the study on the effect of amaranth on the health and nutritional profile of adolescents.

The review has been done in sections as indicated below:

2.1 Importance of adolescence

2.2 Dietary habits of adolescents

2.3 Occurrence of deficiency diseases among adolescents

2.4 Nutrient composition of amaranth

2.5 Formulation and organoleptic evaluation of food products incorporating leafy vegetables

2.6 Impact of leaf supplements on nutritional status

2.1 Importance of adolescence

Adolescence is derived from 'adolescere' – the latin verb meaning to grow into maturity. Mahan and Ress (1984) divided adolescence into three stages; early, middle and late, early adolescence includes the onset of puberty and usually occurs by the age of 10-12 years in girls and 11 to 13 years in boys. Middle adolescence continues through the age of 12 to 15 years in girls and 13 to 16 years in boys. Late adolescence complete the process of somatic growth through the age of 16-21 years in both sexes.

According to Marshall and Tanner (1986) in the past, the word 'adolescence' was used synonymously with puberty and more recently it has become a common practice to use 'adolescence' to refer to the physiological changes associated with puberty.

Population of adolescents in India is 22.5 per cent and the significant segment of the population of Kerala is composed of adolescent and pre-adolescent

group (Bali, 1990). He also reported that rural population of adolescent is about 78.4 per cent while urban population is 21.6 per cent.

Banik (1979) opined that the adolescent is no longer a child, yet he has not reached adult in social, legal or socio economic status. He has also reported that adolescents are particularly vulnerable to conflicts in the socio-cultural matrix which surrounds them in our society. Place (1980) stated that the adolescent stage of life is the period of identifying oneself as a total person.

Wright (1984) stated that adolescence is a period of dynamic changes and these changes occur in all spheres of development of the human potential viz., physical, emotional, intellectual and even spiritual. For majority of young persons the years from 12-16 are the most eventfull ones of their lives so far as their growth and development is concerned (Tanner, 1986).

Shivpuri (1990) has the opinion that adolescent girls in India are more neglected than adolescent boys. She has also pointed out that, they are without proper nutrition, medical care hardly any opportunities for education, employment and self employment. Akkamahadevi *et al.*, (1998) remarked that adolescence is a period of transition during which an individual develops from a child to an adult.

According to Davidson *et al.* (1980) nutritional requirements of adolescents were conditioned primarily by spurt in growth and the additional food requirements are met through increased appetite. Rao (1990) remarked that physical and physiological changes occurring in adolescents impose a great demand on their nutritional requirement.

2.2 Dietary habits of adolescents

Food preferences and food habits of adolescents are formed as a result of complex interaction of many factors within the individual and with that of his

environment (Mahan and Ress, 1984). Rao (1985) opined that teenage period is the time when they exercise full authority in matter of what they will or will not eat.

Socio-economic status of the families were found to have an influence on the inclusion of high cost foods such as margarine, butter, milk and sweets, in the adolescent diet (Prattala, 1988). Manocha *et al.* (1988) studied an inverse relationship between social mobility and dietary intake and it was found that adolescent girls belonging to low income groups being less literate, eat more dense calorific food than females of high income groups and middle income groups who are more literate.

Eating in between meals is a common practice possessed by adolescents. Musgrave *et al.* (1981) opined that there was no real difference in eating snacks between girls and boys. Pearce *et al.* (1987) reported that 15 per cent of adolescent girls surveyed viewed snack eating for fun while 14 per cent viewed snack eating as eating out of control. Bull (1992) opined that developments in western dietary practices have tended to leave adolescents vulnerable to low intakes of energy and some nutrients, as snacking accounts for an increased proportion of dietary intake. He also revealed that achieving a balanced diet is more difficult when the most popular and widely available snack foods are high in sugar or in fat and he emphasizes on the need for more effective education for adolescents on food habits.

Khan and Lipke (1982) reported that compared to other age groups of population adolescents neglected breakfast. While Worthington (1988) observed that female adolescents were found to skip the evening meal, breakfast or lunch more often than males. Phillippe *et al.* (1988) surveyed 225 adolescent girls in France and found that 45 per cent of them skipped breakfast. Lack of time, dieting and not feeling well were the reasons reported by them for skipping of breakfast. Someya *et al.* (1989) reported that adolescents who skipped breakfast took more snacks between meals or late nights.

Haugen (1981) revealed that majority of the adolescents surveyed in Minnesota considered that eating at least one meal a day with family members is important.

Bozz *et al.* (1980) pointed out that intake of high nutritive value food such as eggs and fish were found to be low while intake of fruits and vegetables were below optimum. Perron and Endres (1985) studied the relationship between nutrition knowledge, attitude and dietary practice of adolescents and found that nutrition knowledge and attitudes were positively connected indicating that, the more nutrition knowledge a subject had, the more positive was the adolescent attitude towards nutrition and vice versa. Kohli (1988) reported that adolescents gathered information regarding foods from general reading and mass media and parents also served as source of information.

Miric and Parezanovic (1979) conducted a survey to find out the frequency of consumption of different foods among the adolescents and observed that 21.3 per cent ate eggs three times a week, 72 per cent ate fish once in a week and 68.9 per cent had the habit of drinking black coffee. Pushpamma *et al.* (1982) conducted a diet survey among adolescents in Andra Pradesh and found that intake was low for all foods except cereals. A survey conducted by Sarupriya and Mathew (1988) among adolescents in Rajasthan reported that they followed two meals daily with main food items of chappathi made from maize flour and green chillies for lunch and chappathi with cereal pulse preparation for dinner.

Carlisle *et al.* (1980) observed low acceptance of vegetables among adolescents. They accepted raw vegetables more readily than cooked ones and sweet tasting vegetables over bland and bitter ones. Gnwecki and Pazola (1981) reported that raw vegetables salad items, especially tomato and carrot were popular among adolescents. Desserts were found to be highly appreciated. Musgrave *et al.* (1981) reported that high sucrose snacks were popular and milk was found to be

the most popular drink among adolescents. Sato *et al.* (1984) reported that adolescents preferred meat too.

Chavance and Dumar (1982) reported that average total weekly consumption of beverages of adolescent was seven litres. Krishnakumari and Rao (1983) reported that the intake of fruits and greens by adolescents were negligible.

Sarupriya and Mathew (1988) reported that among the adolescents in a tribal village in Rajastan intake of cereals was higher than recommended but that of pulses, roots and tubers was low and no leafy vegetables, fruits and nuts and oilseeds were taken during the study period. Sarojini and Vijayalakshmi (1989) assessed the adequacy of recommended dietary allowances for adolescent girls and the highest percentage of deficit (100 and 89%) was noted in the intake of fruits and milk and milk products in case of adolescents with heavy activity and the highest percentage deficit was seen in the intake of green leafy vegetables among the moderately active adolescents.

Teenagers often eliminated leafy vegetables and thus lack nutrients which are important for their growth and development (Rajesh, 1991 and Pandey, 1995). Desai (1996) also observed lower consumption of leafy vegetables among adolescents and resulted in low haemoglobin level.

Llamas *et al.* (1996) conducted a study on food intake and dietary habits in a random sample of adolescents in South East Spain and found that they had very low intake of vegetables, milk products and fruits. Fat intake was found to be excess. Intake of cereals and meat was adequate. Pulse intake was insufficient Story and Alton (1996) reported that adolescents consume higher than recommended amounts of dietary fat especially saturated fat and sodium and inadequate amounts of fruits, vegetables and fibre. Low intake of calcium and iron rich foods are of additional concern among adolescent girls. Ahmed *et al.* (1997) collected food frequency data on vitamin A rich foods among female adolescents

in Dhaka city revealed that a large percentage of the subjects did not eat eggs (41%), milk (64%), liver (85%) and sweet pumpkin (85%). However, about 40 per cent of the girls did eat dark green leafy vegetables.

Carbohydrate intake was found to be more or less same in rural and urban adolescents. But urban adolescents were found to consume significantly higher amounts of protein, fat and calories than their rural counterparts (Bindu *et al.*, 1979). McCoy and Kenny (1984) revealed that urban girls consume more energy foods than rural girls. The energy intake on weekend days was consistently higher for girls and boys in all age groups. The proportional intake of fat and sugar was rather high especially on weekend days (Port *et al.*, 1987).

Bundy *et al.* (1982) from their study revealed that snacks provided several dietary components particularly energy, vitamin B6 and iron to adolescent boys and girls. Chavance and Dumar (1982) reported that out of 1535 adolescents surveyed only 13.7 per cent of them ate meals which completely met the recommended dietary allowances (RDA). Marin *et al.*, (1988) reported from their survey that energy intake of adolescent boys did not differ significantly from the ideal values where as in adolescent girls energy supply was found to be deficient. Intake of calcium, zinc, thiamine, niacin and riboflavin were low but the diets were found to be rich in ascorbic acid. Saini and Verma (1989) observed that the daily mean intake of energy in adolescent girls from high socio-economic group was significantly more compared to those from low socio-economic group.

A study on the food and nutrient intake of 185 adolescent boys and girls living in rural areas of 3 regions of Andra Pradesh revealed that the requirements of energy, protein and niacin were met up to 80 to 85 per cent. Only 40 to 50 per cent of the requirement of calcium, riboflavin and thiamine were met. The vitamin A and vitamin C requirement were most inadequately met. The intake of iron was just sufficient in boys and only 62 per cent of the requirement was met in girls (Pushpamma *et al.*, 1982).

Nutritional profile of adolescent girls in Ludhiana was assessed by Nagi *et al.* (1994) and reported that mean daily intake of energy, protein, iron and ascorbic acid was inadequate and the intake of fibre and copper was sufficient when compared to ICMR recommendations. Andersen *et al.* (1995) reported that among the Norwegian adolescents 31 per cent of energy was supplied by fat and 11.4 per cent by sugar. The average daily intake of micronutrients exceeded the Norwegian recommendations except for vitamin D and iron in girls Kochhar *et al.* (1995) assessed the nutrient adequacy of rural adolescent boys in Ludhiana and the results showed that diets were deficient in energy, protein and iron but contained higher amounts of calcium and thiamine than ICMR recommendations.

Nagi *et al.* (1995) assessed the mean nutrient intake of adolescent girls and reported that the mean daily intake of energy protein, iron, calcium, vitamin A and vitamin C was inadequate while the intake of fibre was adequate when compare to ICMR recommendations. The nutrient intake among adolescent girls belonging to poor socio-economic groups of rural area of Rajasthan showed that the diets were 26-36 per cent deficient in energy and 23-32 per cent deficient in protein (Chaturvedi *et al.*, 1996). Mean intake of energy, protein, vitamin B12, folic acid and iron except vitamin C was higher in the urban group compared to rural group of adolescents (Akkamahadevi *et al.*, 1998).

Salar *et al.* (1990) assessed iron status among adolescents in Spain and found that most of the subjects studied had total iron intake lower than RDA. Dietary sources of iron among English adolescents as reported by Moynihan *et al.* (1994) included meat and meat products (18.7%) breakfast cereals (14.8%), bread (11.9%) and potatoes (11.1%) vegetables contributed only 3.4 per cent and the total intake was 11.7 mg/day in boys and 11.2 mg/day in girls. Samuelson *et al.* (1996) reported daily medium intake of iron in boys and girls are 18.7 and 14.2 mg respectively.

The main source of β carotene in the diets of adolescents was cereals accounting for 47.9 per cent of the total ß carotene (Khangaonkar *et al.*, 1990). Ahmed *et al.* (1997) reported that consumption of dark green leafy vegetables seemed to have an important relation with the vitamin A status of adolescent females.

2.3 Occurrence of deficiency diseases among adolescents

According to McCoy and Kenny (1984) adolescence is a critical period in the development of deficiency diseases.

Sarupriya and Mathew (1988) studied the nutritional status of adolescent boys and girls and reported that only 40 per cent had normal body weight and 60 per cent of the subjects had one or other variable signs of deficiency disease.

Kapoor and Aneja (1992) assessed the nutritional status of adolescents in New Delhi belonging to different socio-economic background. The results revealed that 65 per cent of low economic group had weight/height^2 ratio less than reference standard. A study conducted by Nagi *et al.* (1995) on the nutritional status of adolescents in Ludhiana city revealed normal body weight and heights. Chaturvedi *et al.* (1996) assessed the nutritional status of 941 adolescent girls in Rajastan and the body mass index revealed that 8.1 per cent, 6.6 per cent and 78.8 per cent had chronic energy deficiency of grade I, II and III respectively.

Micronutrient deficiency affects approximately 2 billion people world wide or roughly 1/3rd of the human race. As a result of micronutrient deficiency a large proportion of the worlds population is placed at risk of disease, disability and even death (Howson *et al.*, 1998).

Gupta and Saxena (1977) stated that all the nutritional deficiency diseases were more prevalent in rural adolescents than urban adolescents Chopdar

and Mishra (1981) reported that adolescents suffer from vitamin deficiencies, anaemia and other infections like gastrointestinal and upper respiratory infections.

Gupta and Saxena (1977) reported that the incidence of nutritional deficiency diseases were high in vegetarians than non-vegetarian adolescents. They had also reported the occurrence of vitamin A deficiency, anaemia and vitamin B complex deficiencies among the adolescents. Similar findings were also reported by Taneja *et al.* (1978); Lopez *et al.* (1980); Rao (1983); Widhalm *et al.* (1986); Korede and Ajayi (1991) and Nelson *et al.* (1993).

Mei-Qin and Wen-Yu (1990) reported deficiency of protein, calcium, vitamin A, B1 and B2 among Chinese adolescents. Chaturvedi *et al.* (1996) reported signs of vitamin B complex deficiencies (43.6 percent) among the adolescents. NNMB (1996) reported prevalence of bitot's spot and angular stomatitis among adolescents of both sexes. Ahmed *et al.* (1997) assessed vitamin A status of adolescent female factory workers in Dhaka city and found that about 56 per cent had low serum vitamin A concentration and 14 per cent had serum vitamin A deficiency.

Nutritional anaemia is characterized by inadequate erythropoeisis and reduced haemoglobin concentration, which is due to inadequate supply of nutrients like iron, folic acid, ascorbic acid and vitamin B12 (Agarwal, 1991).

Bhatia (1987) found that anaemic subjects have higher heart rates than normal subjects for the same type of work and had poor endurance capacity.

Greenwood (1979) stated that iron deficiency anaemia is undoubtedly one of the most serious public health problem related to nutrition during adolescence.

Raman *et al.* (1985) reported that the incidence of anaemia were higher in rural girls than urban girls. Studies by Mei-Qin and Wen-Yu (1990) among

Chinese adolescents reported iron deficiency anaemia among 46.8 per cent male and 61.8 per cent female adolescents. Hamdaoui *et al.* (1991) reported that 67 per cent of girls and 65 per cent of boys were anaemic among adolescents in Tunis, as defined by WHO.

Kapoor and Aneja (1992) reported that anaemia is a major health problem among adolescent boys and girls belonging to different socio economic backgrounds. Studies conducted by Kanani (1995) revealed that 65 to 75 per cent of the under privileged adolescent girls were anaemic. Ninsing and Shaw (1996) opined that iron deficiency was more prevalent in females than in males and highest rate occurred in teenage girls.

Nagi *et al.*, (1995), Chaturvedi *et al.*, (1996), Ahmed *et al.*, (1997) and Johndhale *et al.* (1999) also reported prevalence of anaemia among adolescents.

Nelson *et al.* (1994) assessed the relation between iron deficiency anaemia and physical performance in adolescent girls and found that physical performance is compromised even at mild levels of anaemia.

Tsui and Nordstrom (1990) and Vizcaino *et al.* (1995) reported high incidence of iron and folate deficiency among adolescents, especially in girls. The folate deficient subjects had lower haemoglobin values than normal subjects.

The assessment of nutritional status of adolescents in New Delhi belonging to different socio economic background by Kapoor and Aneja (1992) reported goitre grade I in a large proportion of adolescents. According to NNMB (1996) report, the total prevalence of goitre grade I was found to be 6.8 per cent in Kerala and 2 per cent of boys and girls had grade II goitre. The overall prevalence was marginally higher in girls (3.9%) as compared to boys (2.8%).

Kapoor and Aneja (1992) reported prevalence of obesity among adolescents belonging to high income groups. Story and Alton (1996) stated that

nutrition related concerns among adolescents include the increasing prevalence of over weight and the use of unhealthy weight loss methods.

2.4 Nutrient composition of amaranth

Leafy vegetables are the green leaves of certain species of plants which have no poinsous alkaloids and do not cause any gastrointestinal disturbance, when they are consumed as food (Aman, 1969).

Vegetables being rich in nutrients, occupy a prominent position among foods and a distinct place in balanced diet. The importance of vegetables, mainly green leafy vegetables is well known as protective foods and suppliers of significant amounts of vitamins, minerals and fibre. Hence a daily intake of at least 100 g of fresh GLV is recommended by the nutrition experts (Reddy, 1999).

The bulk of green leafy vegetables available in India, is comprised of water with in the range of 73.1 to 91.1 per cent (Kaur and Manjrekar, 1975, Jijiamma, 1989).

The moisture content of *Amaranthus* species were analysed and reported that the values ranged from 70.5 to 92.5 per cent (Prakash *et al.*, 1993, Akpanyung *et al.*, 1995, Varalakshmi *et al.*, 1998).

Amaranthus species are known to contain high levels of protein (Mugerwa and Bwabye, 1974). A high yielding short duration variety of *Amaranthus* belonging to *Amaranthus gangeticus* L. released as an improved strain by Tamil Nadu Agricultural University (TNAU), Coimbatore as Co-2 contained 8.5 percent protein in edible matter (Rajagopal *et al.*, 1977). On dry weight basis, Co-3 culture amaranth contained 12.5 per cent protein (Mohideen *et al.*, 1985).

The amino acid composition of certain *Amaranthus* species was evaluated by Vijayakumar and Shanmugavelu (1985) and reported that these are rich in certain essential aminoacids.

According to Castanedac *et al.* (1986) the protein content of Amaranthus is similar to that of spinach George (1986) indicated higher protein content in red pigmented lines of amaranth. Protein in 100 g *Amaranthus gangeticus* and *Amaranthus tricolour* was found to be about 4 g (Gopalan *et al.*, 1989, NIN, 1991a) while Shingade *et al.* (1995) reported 5.3 per cent crude protein in *Amaranthus tricolour*.

Prakash *et al.* (1993) reported that protein content of *Amaranthus* varied from 1.4-4 per cent. Raja *et al.* (1997) reported that amaranth contained 4.94 per cent crude protein. Lower protein content (1.7 g $100g^{-1}$) in 'Arka suguna' a new multicut amaranth variety was reported by Varalakshmi *et al.* (1998) as against the control 'Arve' (*Amaranthus tricolour*). Although the protein content of amaranth is low, it has got good quality protein.

Crude fat of leafy vegetables though present in minute quantities has a special significance because of the presence of carotenoids, vitamin E and K and some polyunsaturated fatty acids among its major constituents (Davidson *et al.*, 1980).

Lipid composition of eight varieties of amaranth was determined by Lorenz and Hwang (1985) and reported that free lipid content varied from 5.69 to 7.23 per cent and bound lipid from 0.42 to 0.91 per cent. Lucas (1988) determined the ether extract of *Amaranthus* to be 2.6 per cent of dry matter.

Shingade *et al.* (1995) estimated the fat content of *Amaranthus triclour* and reported that it contained 0.8 per cent crude fat.

Dietary fibre, the sum of polysaccharides and lignin which are not digested by endogenous secretions of human gastrointestinal tract, is effective in reducing the incidence of obesity hypercholesterolemia, heart disease, diverticular disease and colon disease (Trowell, 1976).

Biochemical analysis of Co-2 *Amaranthus* revealed that it had 1.3 g of crude fibre (Rajagopal *et al.*, 1977). Co-3 culture *Amaranthus* contained 17.4 per cent crude fibre on dry weight basis (Mohideen *et al.*, 1985). *Amaranthus hypochondriacus* and *Amaranthus edulis* were found to have a high content of fibre thus making them less palatable. While Co-1 (*Amaranthus dubius*) and Co-2 (*Amaranthus gangeticus*) types presented a low crude fibre content and both were found to be highly palatable (Vijayakumar and Shanmugavelu, 1985). According to John *et al.* (1987) total dietary fibre content of *Amaranthus tricolor* was 2.3 per cent of edible portion, while Bressani *et al.* (1988) and Shingade *et al.* (1995) reported 1.3 per cent to 1.8 per cent fibre content in it. Lucas (1988) and Mosha *et al.* (1995) indicated that crude fibre content of Amranthus on dry weight basis varied from 9.1 to 21.25 per cent.

Carbohydrate in leafy vegetables differ from non leafy vegetables in that it is stored in the form of starchy grains (Aman, 1969).

John *et al.* (1987) and Gopalan *et al.* (1989) reported the starch content in *Amaranthus tricolor* and *Amaranthus gangeticus* as 0.73 per cent and 6.1 per cent of edible portion respectively. The carbohydrate content of amaranth was 42.4 per cent on dry weight basis (Mosha *et al.*, 1995).

According to Shingade *et al.* (1995), the unconventional leafy vegetables contained more carbohydrates than the conventional sources. He reported that *Amaranthus spinosus* and *Amaranthus tricolor* contained 7.8 per cent and 3.7 per cent of carbohydrate respectively.

Wills *et al.* (1984) analysed the nutrient composition of Chinese vegetables and found that *Amaranthus tricolor* had a starch content of 0.2 per cent of the edible portion.

Green leafy vegetables are rich in minerals especially iron and calcium (Menon, 1980, Philip *et al.*, 1981, Gopalan, 1982, Smith, 1982, Norderide *et al.*,

1996). Other minerals like phosphorus, magnesium, sodium, potassium, copper, iodine, sulphur and boron are also detected in leafy vegetables.

Reddy (1999) reported that green leafy vegetables were inexpensive and rich source of calcium and the average content of calcium in green leafy vegetables is about 300 mg $100g^{-1}$. He also reported that green leafy vegetables were the best source of iron for vegetarians and 100 g of green leafy vegetables provided 4.7 mg of iron per day.

Biochemical analysis of Co-2 amaranth (*Amaranthus gengeticus* L.) revealed that it contained 39.8 mg of phosphorus, 379 mg of potassium, 310 mg of calcium and 19 mg of iron in 100 g of edible matter and Co-3 culture amaranthus contained 0.84 per cent iron, 2.48 per cent calcium, 0.47 per cent phosphorus, 1.35 per cent magnesium and 3.2 per cent potassium on dry weight basis (Rajagopal *et al.*, 1977, Mohideen *et al.*, 1985).

According to Menon (1980) amaranth contained 397 mg Ca/100 g of edible portion and 25.5 mg of iron/100 g of edible portion. The ash content of *Amaranthus* is 19.38 per cent of dry matter and the calcium, phosphorus and iron contents are 5.41 g, 0.29 g and 642.58 mg $100g^{-1}$ of dry matter respectively (Lucas, 1988). *Amaranthus gangeticus* contained 2.7 g of minerals per 100 g which consisted of 397 mg calcium, 83 mg phosphorus and 25.5 mg iron, while every 100 g edible portion of *Amaranthus tricolor* contained 2.7 g minerals, 397 mg calcium and 3.49 mg iron and 341 mg potassium (Gopalan *et al.*, 1989, NIN, 1991a). According to Shingade and Chawan (1996), *Amaranthus tricolor* is comparatively high in phosphorus, potassium, calcium and magnesium and micronutrients like iron and boron. Varalakshmi *et al.* (1998) reported that the phosphorus, calcium, potassium, magnesium, iron and sulphor content of new multicut amaranth 'Arka Suguna' had higher mineral content than the control variety 'Arve' (*Amaranthus tricolor*).

The β carotene content of green leafy vegetables vary from 5000-7500 µg $100g^{-1}$. Among the green leafy vegetables drumstick leaves, agath, amaranth, curry leaves and coriander contain very high content of β carotene (6000 to 9000 µg $100g^{-1}$) Reddy (1999).

By inclusion of 30-50 g of green leafy vegetables like amaranth an adult can meet his requirement of vitamin A (Gopalan *et al.*, 1989).

Every 100 g of edible portion of *Amaranthus tricolor* contain 9200 I.U. of vitamin A (NIN, 1991b). Co-3 amaranthus contained 11.04 mg of carotene in 100 g of fresh matter (Mohideen *et al.*, 1985). 'Arka Suguna' a pure line selection amaranth from Taiwanese introduction is rich in vitamin A (Varalakshmi *et al.*, 1998).

Carotenoid content of *Amranthus hypochondriacus* varies from 12-20 mg $100g^{-1}$ (Prakash *et al.*, 1993). The leaves of *amaranthus viridis* a cultivated leafy vegetable in Southern Mali are reported to be rich in β carotene (3290 µg $100g^{-1}$) (Norderide *et al.*, 1996).

According to NIN (1994) the β carotene content and percentage β carotene were higher in medium textured leaves than in the tender and coarse samples.

Green leafy vegetables are rich in vitamin C, which is required to keep the gums in a healthy condition (Menon, 1980, Gopalan *et al.*, 1989). Some green leafy vegetables like spinach, amaranth, fenugreek, mustard, coriander leaves are equally good source of vitamin C as fruits (Sreeramulu *et al.*, 1983). Reddy (1999) reported that the green leafy vegetables like amaranth, agathi, mustard leaves and broccoli contain adequate amounts of vitamin C in the range of 120-220 mg $100g^{-1}$.

The ascorbic acid content of raw amaranth was found to be 96 mg $100g^{-1}$ (Devadas *et al.*, 1973). While Mohideen *et al.* (1985) reported that Co-3 amaranth culture contained 35.9 mg of ascorbic acid in 100 g of fresh matter. Every 100 g edible portion of *Amaranth tricolor* contained 99 mg of vitamin C (NIN, 1991a). Varalakshmi (1998) stated that leaves and tender stems of amaranth are rich in vitamin C.

2.5 Formulation and organoleptic evaluation of food products incorporating leafy vegetables

Quality is the ultimate criterion of the desirability of any food product to the consumer. Overall quality depends on the quantity, nutritional and other hidden attributes and sensory quality (Ranganna, 1977).

According to Bodyfelt *et al.* (1988) measuring the sensory properties and determining the importance of these properties as a basis for predicting acceptance by the consumers represent major accomplishment for sensory evaluation. For consumers, the sensory attributes like colour appearance, feel, aroma, taste and texture are the deciding factors in food acceptance (Pal *et al.*, 1995).

Fathima and Beegum (1998) reported microwave drying as a highly suitable method for greens such as amaranth, where as it is moderately suitable for shepu and fenugreek and less suitable for coriander and mint. Dried powder of green leafy vegetables, a rich source of iron and β carotene was exploited in preparation of snack products by Kushwaha *et al.* (1998) and the results showed that spinach leaf powder and cauliflower leaf powder can be used to alleviate the problem of micronutrient deficiencies.

Lakshmi and Vimala (1998) conducted studies for the development of nutritious dehydrated green leafy vegetable powders and blends using amaranth (*Amaranthus gangeticus*), curry leaves (*Murraya koenigis*), gogu (*Hibiscus*

cannabinus) and mint (*Mentha spicata*). Amaranth powder was found to be rich in proteins, calcium, iron, magnesium and zinc. Curry leaf powders was rich in fibre ascorbic acid, β carotene and copper while gogu and mint powders were fair source of all the nutrients.

In order to make green leafy vegetables acceptable to armed forces deployed at high altitudes, deserts and seas, instant vegetable-dhal curry mixes based on spinach (*Spinacia oleracea*), fenugreek (*Trigonelia foenum graecum*), drumstick leaves (*Moringa oleifera*), khatipalak (*Rumex vesicarius*) and shepu (*Peneedanum graveoleus*) were developed at the Defence Food Research Laboratory, Mysore (Patki *et al.*, 1998). Premavalli *et al.* (1998) analysed two instant savoury mixes based on fenugreek leaves and chakota leaves with turdhal and green gram dhal with suitable spice mixtures which have been developed to supplement the vitamins, minerals and proteins in the packed rations of Armed Forces. According to the authors, these products contained 15 and 28 per cent fat and 13 and 26 per cent protein and had good stability during storage.

In order to incorporate leafy vegetables in the food supplements of children in the low socio-economic groups of Bangalore and Mysore. Rau *et al.* (1998) formulated six food products viz. uppittu, bisbele bhath, mixed pulses, sandwich, chappathi and dhokla. The green leafy vegetables were incorporated as a source of iron and vitamin A in amounts at two levels; the amount at which the products were accepted and also the amount needed to provide the entire days. Recommended Dietary Intake (RDI) for children. The study revealed that an amount of 50 g could be incorporated in their preparations to obtain an acceptable product. The amount needed to provide the entire days RDI was found to be still higher.

Kowsalya and Mohandas (1999) conducted a study on the acceptability of cauliflower leaves and revealed that cauliflower leaves are accepted well in its meal forms namely poriyal and kootu as well as in the incorporated recipes (10%

and 20%) such as adai, vadai and chappathi. It was also found to be rich in terms of macro and micronutrients.

Islam *et al.* (1987) conducted a study on the sensory evaluation of *Atriplex triangularis* and reported that these leaves rated similar to spinach in all the four quality attributes viz. colour flavour, texture and overall acceptability. In the study, it was also revealed that *Atriplex triangularis* leaves are accepted more than mustard greens.

Padmavathi and Rao (1990) used *Sauropus androgynus* leaves in the recipes traditionally prepared with common leafy vegetables in Andra Pradesh, and found that the preparations were highly palatable and acceptable.

Alleman *et al.* (1996) evaluated six *Amaranthus* genotypes in South Africa, for taste and acceptability as a source of nutrition. Acceptability of the leaf material for human consumption was tested for both taste and texture. According to them *Amaranthus tricolor* and *Amaranthus hypochondriacus* had the best tasting, significantly better than that of *A. cruentus* and among the *A. hybridus* cultivars. *A. tricolor* had best texture.

Fathima and Beegum (1998) found that the microwave drying affected certain physical characteristics of all the greens (coriander, mint, fenugreek, amaranth and shepu) like colour, appearance and odour. Acceptability scores for coriander and mint were low for flavour and colour, but amaranth had scores similar to that of fresh.

Kala *et al.* (1998) compared the sensory attributes of microwave cooked and conventionally cooked (boiling/ pressure cooking) green leafy vegetables viz. Amaranth (*A. gangeticus*), kilkeerai (*A. tricolor*), shepu (*Peucedanum graveolous*) and spinach (*spinacia oleracea*). Results of the sensory analysis showed that only the colour of cooked greens was significantly affected due to cooking methods and microwave cooked greens were preferred to conventionally cooked greens.

Snack items viz. namakpara, kachari, biscuit and besan sev prepared by incorporating spinach leaf powder and cauliflower leaf powder were also found to be acceptable upon sensory evaluation (Kushwaha *et al.*, 1998).

Vegetable dhal curry mixes developed at Defence Food Research Laboratory, Mysore scores 8.2 to 8.8 overall acceptability score on nine point hedonic scale (Patki *et al.*, 1998). The reconstituted savoury mixes formulated at Defence Food Research Laboratory, Mysore viz. spice methi dhal mix and spice chakota mix had sensory scores of 7.2 and 7.5 on a nine point hedonic scale (Premavalli *et al.*, 1998).

Neeliyara (1998) studied the acceptability of the leaves of five genotypes of winged bean using score card. Among the quality attributes, doneness had obtained the highest score in all the genotypes and texture obtained the least score.

2.6 Impact of leaf supplements on nutritional status

The growth, health and efficiency of a population are determined by adequate food supply furnishing all the essential nutrients in the required quantities.

Doraiswamy *et al.* (1969) noted in a study, in 6 to 12 years old boys in Mysore, India, that when ragi diets were supplemented with leaf protein concentrate for six months there was a significant increase in the haemoglobin concentration.

Olatunbosun *et al.* (1972) gave leaf protein concentrate to 26 severely malnourished infants and children in Nigerian hospital. They remarked on the spontaneous remission of anaemia and attributed to this, at least inpart, to the high folic acid content of the leaf concentrate being fed.

Devadas and Saroja (1979) conducted a study on the availability of iron and β carotene from amaranth among children and indicated that *Amaranthus* species are excellent sources of iron and β carotene and daily inclusion of amaranth in the diets of children could help to alleviate iron and vitamin A deficiencies.

A study conducted by Devadas *et al.* (1981) on leaf protein concentrate feeding trial in preschool children showed that β carotene and iron content of leaf protein appear to have a higher beneficial effect in serum vitamin A and haemoglobin levels.

In Pakistan, Shah *et al.* (1981) reported that a leaf protein supplemented diet was more effective than an isonitrogenous isocaloric milk diet in increasing haemoglobin values. Mathur *et al.* (1989) reported that the leaf protein containing snacks were very effective in raising haemoglobin levels. The nutrient content of the leaf protein snacks was higher in terms of iron, protein, β carotene and folic acid which explained the improved haemoglobin picture.

A daily supplementation of the diet of selected rural children of the age 2-6 years with 140 g papaya fruit 40 g of amaranth leaves and 63.5 g of carrots each furnishing 1200 µg of β carotene was conducted by Devads and Saroja (1987) indicated significant increase in serum vitamin A levels.

MATERIALS AND METHODS

MATERIALS AND METHODS

An investigation on 'Effect of amaranth on the health and nutritional profile of adolescents' was carried out to find out the effect of supplementing amaranth in the diets of adolescents (13-15 years). This chapter deals with the methods and procedures followed in the various phases of research and they are given under the following headings.

3.1 Selection of the area

3.2 Selection of samples

3.3 Plan of study

3.4 Methods adopted for the study

3.5 Development of tools and conduct of the study

3.6 Statistical analysis

3.1 Selection of the area

Juvenile home and an orphanage in Trichur district were selected for the study by conducting a screening test with the help of a physician for the prevalence of anaemia.

3.2 Selection of the samples

Details of adolescents in the age range of 13-15 years residing in the two selected institutions were collected. From this list 60 anaemic adolescents, each from juvenile home and orphanage were selected randomly for the study. The selected subjects were categorized into three groups consisting 20 adolescents in each group i.e., one control group and two experimental groups, to supplement $2/3^{rd}$ and full recommended dietary allowances (RDA) of leafy vegetables. Thus 60 adolescent boys from juvenile home and 60 adolescents girls from the orphanage

were selected for the study. Hence the total sample for the study comprised of 120 adolescents.

3.3 Plan of study

The study envisaged the following plan of work.

i) Institutional survey to collect the available information regarding the food consumption pattern of samples.

ii) Preparation of amaranth recipes and organoleptic evaluation of the prepared recipes.

iii) Selection of 10 highly acceptable amaranth recipes.

iv) Nutrient analysis of fresh amaranth and selected recipes

v) Feeding trial with the selected recipes

vi) Assessment of nutritional status through

   a) Anthropometric measurements like height and weight of adolescents

   b) One day food weighment survey to assess the actual food and nutrient intake

   c) Clinical examination to identify deficiency symptoms

   d) Biochemical estimation of blood for haemoglobin, RBC count and packed cell volume

vii) Functional performance

viii) Analysis of data using suitable statistical techniques

3.4 Methods adopted for the study

The institutional survey was done by direct interview method. According to Lindzey (1954) interview method is a face to face verbal exchange by which the interviewer attempts to elicit information or expression of opinion or belief from the other person. Interview method is reported to be the most suitable way to collect data since it proceeds systematically and enables quick recording (Devadas and Kulandaivel, 1975 and Bass *et al.*, 1979). In the present study, a

questionnaire was developed to collect information regarding the food consumption pattern in the institutions.

Organoleptic qualities plays an important role in evaluating the quality of food product. Sensory method, in which palatability is evaluated by a panel of judges is essential for every cooking procedure because they answer all important questions of the food like taste, smell appearance, colour and texture (McDernott, 1992).

In this study 20 amaranth recipes were prepared by using standard procedure suggested by Abraham (1997) and organoleptic evaluation of the 20 recipes was conducted to select 10 highly acceptable amaranth recipes for feeding trial.

Analysis of nutrients

The fresh and 10 highly acceptable amaranth recipes were analysed for the following nutrients

1) Protein, 2) Starch, 3) Soluble carbohydrate, 4) Fibre, 5) Calcium, 6) Iron, 7) β carotene, 8) Vitamin C. All the analysis were carried out in triplicate samples.

The protein content was analysed in dried samples. Nitrogen content of the samples was estimated by colorimetry using Nessler's reagent (Fisher, 1961), which was then multiplied by a factor of 6.25 to get the protein content.

The starch content was analysed in the dried samples colorimetrically as suggested by Sadasivam and Manikam (1992).

The soluble carbohydrate content was analysed in the dried samples colorometrically (Sadasivam and Manikam, 1992).

Crude fibre content of the dried samples was estimated by acid-alkali digestion method as suggested by Chopra and Kanwar (1978).

For estimating the calcium and iron content of dried samples, a diacid extract of the sample was prepared and was estimated in an Atomic Absorption Spectrophotometer (Perkin-Elmer, 1982).

The β carotene content of the dried samples was estimated by the method of A.O.A.C. (1970) using saturated n-butanol.

The vitamin C content of the fresh samples was estimated by the method of A.O.A.C. (1955) using 2,6, dichlorophenol indophenol.

According to Devadas and Easwaran (1991) supplementary feeding programmes using low cost foods is beneficial to solve the problem of malnutrition in India. In the present study, the feeding trial using amaranth was carried out among adolescents for a period of six months.

Anthropometric indices, presence of clinical deficiency signs, dietary assessment actual food intake and biochemical estimation were widely used as direct parameters of nutritional status (Aebi, 1983). Assessment of Nutritional status could best be achieved by the use of one or combination of several methods. Hence in this study, the following methods were used to assess the nutritional status of adolescents.

a) Recording of anthropometric measurements – height and weight
b) Monitoring actual food intake
c) Conducting clinical examination
d) Biochemical estimation of blood for haemoglobin, RBC count and packed cell volume

Anthropometry has been accepted as an important tool for assessment of nutritional status (Weisell andFrancois, 1982; Vijayaraghavan, 1987, Sharma and Kalia, 1990, Reddy *et al.*, 1993).

According to Rao and Vijayaraghavan (1996) anthropometry could help in the assessment of subclinical stages of malnutrition.

Height deficit is an indicator of long term malnutrition. The extent of height deficit in relation to age as compared to regional standards could be regarded as a measure of malnutrition (Gopaldas and Seshadri, 1987).

Among the environmental factors which influence the height of an individual, nutrition and morbidity are very important because inadequate dietary intake or infections reduce nutrient availability at cellular level leading to growth retardation and stunting (Rao and Vijayaraghavan, 1996).

Body weight is most widely used and the simplest reproducible anthropometric measurement for the evaluation of nutritional status of young children (Swaminathan, 1987 and Rao and Vijayaraghavan, 1996). According to Vijayaraghavan (1987) body weight is sensitive even to small changes in nutritional status due to childhood morbidities and rapid loss of body weight in children could be considered as an indicator of potential malnutrition.

Weight for height is a useful, age independent ratio and gives an indication of current nutritional status (Gopaldas and kanani,1987and Rao and Vijayaraghavan,1996) .

Body mass index (BMI) has been shown to be a good indicator of nutritional and functional status (NIN, 1990). According to Rao and Vijayaraghavan (1996) BMI provides a reasonable indication of nutritional status and BMI <18.5 indicates undernutrition and more than 25.0 is considered as indication of obesity.

In the present study, height and weight of adolescents were recorded before and after the feeding trial.

Diet survey constitute an essential part of any complete study of nutritional status of an individual or groups and provide essential information on nutrient levels, source of nutrition, food habits, and attitudes (Gopaldas and Seshadri, 1987).

Weightment method of diet survey could give accurate values of dietary intake (Gore *et al.*, 1977).

According to Swaminathan *et al.* (1987) and Thimmayamma and Rau (1996) it is ideal to conduct the survey for seven consecutive days to capture a true picture of the diet. However, according to the authors depending on the purpose of the investigation the period of survey can either be reduced on increased.

Rao (1975) stated that any single day or two day weighment method could be also an efficient tool as that of seven days. Hence in this study, one day food weighment survey was conducted to determine the actual food and nutrient intake of adolescents.

Clinical examination is an important sound method of assessing the nutritional status of a community (Jelliffe, 1966 and Kamath, 1986). According the Swaminathan (1987) it provides direct information of signs and symptoms of dietary deficiencies prevalent among people.

Rao and Vijayaraghavan (1996) opined that clinical examination reveals the anatomical changes due to malnutrition that can be diagnosed by naked eye. In the present study, clinical examination of adolescents was conducted to assess the signs and symptoms of nutritional deficiencies.

Biochemical investigations represented the most objective assessment of the nutritional status of an individual providing pre or subclinical information (Sausberlich *et al.*, 1977). Daphna (1979) pointed out that biochemical tests were of utmost importance in the assessment of individual nutriture.

According to Soof (1967) haemoglobin levels are satisfactory indices for detecting iron deficiency. According to Dacie and Lewis (1975) packed cell volume can be used as a simple screening test for anaemia. In addition, in conjugation with estimation of the haemoglobin and RBC count. Knowledge of PCV enables the calculation of red cell indices.

The haematological indices namely haemoglobin level, red blood cell count and packed cell volume of the samples were estimated by the procedures suggested by Dacie and Lewis (1975).

Sathyanarayana (1988) reported that nutritional deprivation appeared to impair work capacity, physical fitness and the capacity to handle, moderate work loads. The functional performance of adolescents were measured by Harvard Step test suggested by Brouha (1943).

3.5 Development of tools and conduct of the study

To collect information regarding the institution a questionnaire was developed. The schedule was aimed to explore the dietary habits and food consumption pattern of the inmates of the institution including frequency of use of foods, daily meal pattern and diet during illness. The details were obtained from the head of the institution by interview method. The questionnaire was pre-tested and the details are presented in Appendix I.

The preparation of amaranth recipes were based on traditional South Indian dishes. The amaranth was incorporated into the preparation which are usually served in the institution like pittu, chappathi, thoran etc. using standard procedures. Twenty recipes were prepared and the prepared dishes are listed below.

1) Cheera rice
2) Cheera chappathi
3) Cheera pittu

4) Aval cheera uppuma
5) Cheera vada
6) Cheera stew
7) Cheera cutlet
8) Cheera curd curry
9) Cheera dal curry
10) Cheera curry
11) Cheera fish curry
12) Cheera fish foogath
13) Cheera minced meat thoran
14) Cheera jack fruit seed thoran
15) Cheera green gram thoran
16) Cheera egg thoran
17) Cheera thoran
18) Cheera dal maseel
19) Cheera omlette
20) Cheera pachadi

Organoleptic evaluation of the recipes was carried out to select 10 highly acceptable amarath recipes. A series of acceptability trials were carried out using simple triangle tests at the laboratory level to select a panel of judges (Jellinek, 1985). Ten technical experts and twenty adolescents were selected for organoleptic evaluation. The score card developed for the study is presented Appendix II. Five quality attributes like, appearance, colour, flavour, texture and taste were included. Each of the above mentioned quality was assessed by a five point hedonic scale. The ten recipes, selected after organoleptic evaluation are given in Appendix III.

Nutrient analysis of fresh amaranth and the selected ten highly acceptable amaranth recipes were carried out using standard procedure and the values were expressed in fresh weight basis.

The ten highly acceptable amaranth recipes were used for feeding trial. The feeding experiment was conducted for a period of six months by continuously serving the different recipes alternately. The quantity of amaranth fed to the experimental groups I and II were 2/3rd RDA and full RDA of leafy vegetables suggested by ICMR (1984). Control group was served the basal diet. Prior to feeding trial, the adolescents were dewormed using Albendazole tablets I.P. (400 mg). Anthropometry, clinical, blood profile and functional performance of adolescents were carried out in both control and experimental group before and after the feeding trial.

The anthropometric measurements viz. height and weight were taken as suggested by Jelliffe (1966) and Rao and Vijayaraghavan (1996). The height of the adolescents was measured using a fibre glass tape. The subject was asked to stand erect without shoes, with the heels, buttocks, shoulders and occiput against the wall.

Weight of the adolescents was measured using a bathroom balance which was checked by calibrating with standard weights. Weight was recorded with minimum clothings on the subject.

One day food weighment survey was conducted to assess the actual food consumption of adolescents. The schedule used to assess the actual food intake is given in the Appendix IV. The weight of raw ingradients included in the meal for a day and the cooked weight of the same were recorded. The exact amount of the food consumed by the adolescent was also recorded. All the weights were taken with standard measuring cups and spoons and also by means of food weighing balance. The amount of food items consumed by the adolescent was then converted to its equivalents. The nutrients available from the food consumed were computed using food composition tables (Gopalan *et al.*, 1989).

Clinical examination of the samples was conducted with the help of a qualified physician before and after the supplementation study. The schedule used for this purpose is given in the Appendix V.

The biochemical estimation of blood was conducted for haemoglobin, RBC count and packed cell volume using standard procedures suggested by Dacie and Lewis(1975).

The functional performance of adolescents were assessed by Harvard step test suggested by Brouha (1943) In this test, the subject performs a stepping exercise on an 18 inch bench for 4 minutes The lead foot may be changed during the test, but not more than three times Immediately upon completion of the exercise, the testee sits down and the pulse count is taken. The score is derived by the formula

$$\text{Index} = \frac{\text{Duration of exercise in seconds} \times 100}{5.5 \times \text{pulse count}}$$

3.6 Statistical analysis

The various statistical techniques used in this study to analyse the results were percentage analysis, paired 't' test and analysis of variance.

RESULTS

RESULTS

The results of the study entitled 'Effect of amaranth on the health and nutritional profile of adolescents' are presented in this chapter under the following sub headings.

4.1 Food consumption pattern of the inmates in the institutions

4.2 Organoleptic qualities of amaranth recipes

4.3 Nutrient composition of fresh amaranth and amaranth recipes

4.4 Effect of feeding amaranth on the health and nutritional status of adolescents

4.5 Effect of feeding amaranth on the functional performance of adolescents

4.1 Food consumption pattern of the inmates in the institutions

Food consumption pattern of the inmates was assessed with respect to the food habits, frequency of use of food items, accounting system, meal pattern, methods of cooking, cooking pattern, details of food preservation and foods given during special occasions and are furnished below.

The inmates in the institutions were nonvegetarians. In both the institutions, rice formed the staple food.

The details of the frequency of use of various food items by the institutions are presented in Table 1.

Table 1. Frequency of use of different food items in the two institutions

Details	Institution I (Boys)	Institution II (Girls)
Cereals	Daily	Daily
Pulses	Daily	Weekly twice
Green leafy vegetables	Occasionally	Occasionally
Roots and tubers	Daily	Weekly thrice
Other vegetables	Daily	Daily
Fruits	Occasionally	Occasionally
Milk	Daily	Daily
Egg	Monthly twice	Weekly once
Meat	Weekly once	Occasionally
Fish	Weekly once	Weekly twice
Fats and oils	Daily	Daily
Sugar	Daily	Daily
Jaggery	Occasionally	Occasionally
Spices and condiments	Daily	Daily

The table reveals that the inmates of both institutions used cereals, other vegetables, milk, fats and oils and sugar, spices in their daily diet. The inmates of institution I consumed pulses and roots and tubers every day but in institution II,they used pulses twice a week and roots and tubers thrice a week. Meat and fish were used once a week by the inmates of institution I whereas it was occasional and twice a week respectively in institution II. Egg was used monthly twice in the diet of institution I and weekly once in institution II. Green leafy vegetables, fruits and jaggery were part of the diet in both the institutions only occasionally.

The details of accounting system followed in the two institutions revealed that in both the institutions they maintained written accounts of their income and expenditure on a daily basis.

Meal pattern followed in the institutions were studied with respect to meal planning, basis for meal planning, number of meals per day, time schedule if followed and food distribution pattern and the results indicated that advanced meal planning was done in both the institutions. The planning of meal was based on the availability of food in institution I and availability of money in institution II.

Three meals were served in both the institutions and specific time schedule was adopted for serving the meals. In both the institutions equality was maintained in the distribution of food.

Regarding the cooking methods followed, in both the institutions cereals were cooked in excess water, which was later drained off. Absorption method was adopted in the case of green leafy vegetables by the two institutions while boiling was the method of cooking adopted for pulses, other vegetables, roots and tubers, milk, egg and fish. Boiling and frying methods were adopted in case of meat by institution I and II. Fruits were eaten as such by inmates of institution I whereas the inmates of institution II consumed fruits as such as well as after steaming.

Cooking pattern followed in the two selected institutions was studied and the results revealed that in both the institutions cooking was done thrice a day. It was noticed that cook and children participated in cooking in institution I whereas in institution II cooking was done by cook and her assistants. For cooking, ordinary chullah was used in institution I, but in institution II Ordinary chullah and LPG stove was used for cooking purposes. The habit of drinking boiled water was seen in institution II whereas in institution I, they used water without boiling for drinking.

The details of preservation of foods in the two institutions indicated that both the institutions preserved mango, lime and gooseberry as pickles and in both the institutions they never purchased preserved foods.

The foods given during special occasions and illness were studied and revealed that special foods like payasam, snacks, non-vegetarian foods and sadhya were prepared on festival occasions like Christmas and Onam. They usually do not celebrate birthdays of the inmates. Both the institutions, usually gave modified diets during illness which includes kanji, pickles, pappad, black tea or coffee, rusk, bread etc. depending on the diseased condition.

Table 2. Mean scores for the acceptability test of amaranth recipes

Quality parameters	Recipes																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Appearance	2.27	2.27	1.70	3.87	2.33	2.43	2.66	3.93	4.07	3.93	3.90	2.73	4.13	3.67	3.70	2.42	1.93	3.90	1.90	4.03
Colour	2.10	2.03	2.20	3.97	2.40	2.96	3.03	3.77	3.16	3.93	3.43	2.90	3.53	3.43	3.92	2.50	1.90	3.60	2.14	3.30
Flavour	1.90	1.90	2.20	2.83	2.30	1.90	2.80	3.23	3.37	2.83	2.96	2.73	3.03	3.23	2.97	2.43	1.60	3.80	1.73	3.40
Texture	2.63	1.97	2.73	3.07	3.03	2.00	3.03	3.46	3.06	3.17	3.66	3.00	4.06	3.26	3.73	3.13	2.90	2.80	3.13	3.70
Taste	1.97	2.00	1.83	3.66	1.90	2.50	2.80	4.00	4.33	3.90	4.17	3.20	3.76	4.23	4.16	2.60	2.10	4.07	2.10	4.03
Total	10.87	10.17	10.66	17.40	11.96	11.79	14.32	18.39	17.99	17.76	18.12	14.56	18.51	17.82	18.48	13.08	10.43	18.17	11.00	18.46

Maximum score = 25

1) Cheera rice
2) Cheera pittu
3) Cheera aval uppuma
4) Cheera chappathi
5) Cheera stew
6) Cheera curd curry
7) Cheera fish curry
8) Cheera curry
9) Cheera vada
10) Cheera cutlet
11) Cheera dal maseel
12) Cheera dal curry
13) Cheera minced meat thoran
14) Cheera green gram thoran
15) Cheera thoran
16) Cheera jack fruit seed thoran
17) Cheera fish foogath
18) Cheera egg thoran
19) Cheera omlette
20) Cheera pachadi

4.2 Organoleptic qualities of amaranth recipes

The acceptability study of twenty amaranth recipes were conducted by score card method to select ten highly acceptable amaranth recipes for feeding trial. A five point hedonic scale was used to score different characters like appearance, colour, flavour texture and taste and mean scores obtained for different characteristics are presented in Table 2.

From Table 2, it can be seen that while taking all the quality parameters into consideration the mean score varied between 1.60 and 4.33. When the character appearance was analysed, the maximum score of 4.13 was obtained for cheera minced meat thoran and the minimum score of 1.70 was obtained for cheera aval uppuma.

Cheera chappathi had the maximum score of 3.97, when the character colour was analysed. Cheera fish foogath had the minimum score of 1.90.

The maximum score of 3.80 and minimum score of 1.60 were obtained for cheera egg thoran and cheera fish foogath respectively, when the character flavour was studied.

The character texture obtained a maximum score of 4.06 for cheera minced meat thoran and a minimum score of 1.97 for cheera pittu.

The maximum and minimum score obtained for the character taste were 4.33 and 1.83 for cheera vada and cheera aval uppuma respectively.

When all the characters were analysed together, to find out the overall acceptability of the 20 recipes, it was found that the highest score of 18.51 was obtained for cheera minced meat thoran and the lowest score of 10.17 was obtained for cheera pittu.

The ten amaranth recipes which had obtained the highest total score in the acceptability study were selected to conduct the feeding trial. The ten selected recipes and their total scores obtained are furnished in Table 3.

Table 3. Details of recipes selected for the feeding trial

Recipes	Total score
Cheera minced meat thoran	18.51
Cheera thoran	18.48
Cheera pachadi	18.46
Cheera curry	18.39
Cheera egg thoran	18.17
Cheera dal maseel	18.12
Cheera vada	17.99
Cheera green gram thoran	17.82
Cheera cutlet	17.76
Cheera chapathi	17.40

Maximum total score = 25

The Table 3 reveals that among the ten recipes chosen for feeding trial cheera minced meat thoran obtained the maximum score of 18.51 and cheera chappathi obtained the minimum score of 17.40 out of maximum score of 25.

4.3 Nutrient composition of fresh amaranth and amaranth recipes

The fresh amaranth and selected ten recipes were analysed for protein, starch, soluble carbohydrate, crude fibre, calcium, iron, beta carotene and vitamin C. The mean values obtained for each nutrient is given in Table 4.

4.3.1 Protein

The crude protein content of fresh amaranth was found to be 3.34 per cent. The protein content of amaranth recipes varied between 1.81 and 8.34 per cent with the recipe cheera minced meat thoran having the maximum protein content and cheera cutlet with minimum protein content. It can be seen from the table that certain recipes are showing higher values for protein content than fresh

Table 4. Nutrient composition of fresh amaranth and amaranth recipes (fresh weight basis).

Details	Protein g $100g^{-1}$	Starch g $100g^{-1}$	Soluble carbohydrate g $100g^{-1}$	Crude fibre g $100g^{-1}$	Calcium mg $100g^{-1}$	Iron mg $100g^{-1}$	ß carotene µg $100g^{-1}$	Vitamin C mg $100g^{-1}$
Fresh amaranth	3.34	0.20	1.68	1.72	197.39	20.52	15064	136.55
Cheera minced meat thoran	8.34	0.97	2.11	0.12	154.80	20.23	6155	68.40
Cheera thoran	2.40	0.71	2.36	2.10	191.56	21.29	10048	75.85
Cheera pachadi	3.23	0.60	2.94	1.37	182.80	19.44	6396	64.62
Cheera curry	2.92	0.83	2.10	2.76	188.36	20.59	8025	57.33
Cheera egg thoran	7.76	0.31	2.13	0.78	154.15	17.80	6723	53.79
Cheera dhal maseel	3.42	7.72	3.58	1.28	155.83	17.76	5993	61.66
Cheera vada	4.72	19.65	7.85	2.36	152.98	19.44	10280	72.52
Cheera green gram thoran	4.16	9.66	3.34	2.91	165.11	18.02	5696	72.71
Cheera cutlet	1.81	9.38	2.04	1.06	168.64	15.61	8378	69.50
Cheera chappathi	4.65	33.23	12.70	1.31	152.98	13.99	5205	69.42

amaranth. The recipes, cheera dal maseel (3.42), cheera egg thoran (7.76), cheera chappathi (4.65), cheera vada (4.72), cheera minced meat thoran (8.34) and cheera green gram thoran (4.16) had higher protein content whereas cheera thoran (2.40), cheera cutlet (1.81), cheera pachadi (3.23) and cheera curry (2.92) had lower protein content than fresh amaranth.

4.3.2 Starch

The starch content of fresh amaranth was found to be 0.20 per cent. The starch content of amaranth recipes ranged from 0.31 to 33.23 per cent. Among the recipes cheera chappathi had the highest starch content and cheera egg thoran had the lowest starch content. On comparison with the starch content of fresh amaranth, it was found that all the amaranth recipes had higher starch content.

4.3.3 Soluble carbohydrate

The fresh amaranth had a soluble carbohydrate content of 1.68 per ...e.... In the recipes, the soluble carbohydrate content varied from 2.04 to 12.70 per cent with cheera chappathi having the highest content and cheera cutlet having the lowest soluble carbohydrate content. All the recipes showed a higher soluble carbohydrate content compared to fresh amaranth.

4.3.4 Crude fibre

The fibre content of fresh amaranth was 1.72 per cent. The fibre content of different recipes varied between 0.78 and 2.91 per cent with the highest fibre content in cheera green gram thoran and the lowest in cheera egg thoran. The fibre content of amaranth recipes was compared with that of fresh amaranth. It was found that cheera thoran (2.10%), cheera vada (2.36%), cheera green gram thoran (2.91%) and cheera curry (2.76%) had higher fibre content than the fresh amaranth and the recipes cheera cutlet (1.06%), cheera dal massel (1.28%), cheera egg

thoran (0.78%), cheera chappathi (1.31%) and cheera minced meat thoran (0.12%) had lower fibre content.

4.3.5 Calcium

The fresh amaranth had a calcium content of 197.39 mg 100 g^{-1}. The calcium content of recipes ranged from 152.98 to 191.56 mg 100 g^{-1} with maximum calcium content in cheera thoran and the minimum in cheera vada. All recipes showed a lower calcium content compared to fresh amaranth.

4.3.6 Iron

The iron content of fresh amaranth was 20.52 mg 100 g^{-1}. The iron content of recipes varied between 13.99 to 21.29 mg 100 g^{-1} with the highest iron content in cheera thoran and the lowest in cheera chappathi. Cheera thoran (21.29 mg 100 g^{-1}) and cheera curry (20.59 mg 100 g^{-1}) showed higher iron content than the fresh amaranth. The other recipes showed lower iron content.

4.3.7 β carotene

The fresh amaranth had a β carotene content of 15064 µg 100 g^{-1}. In the recipes, the β carotene content ranged from 5205 to 10280 µg 100 g^{-1}, with the highest β carotene content in cheera thoran and lowest content in cheera chappathi. All recipes had lower β carotene content when compared with fresh amaranth.

4.3.8 Vitamin C

The fresh amaranth had a vitamin C content of 136.55 mg 100 g^{-1}. The vitamin C content of amaranth recipes ranged from 53.79 to 75.85 mg 100 g^{-1} with the maximum vitamin C content in cheera thoran and the minimum in cheera egg thoran. All recipes had vitamin C content lower than that of fresh amaranth.

Table 5. Comparison of mean height of adolescents with the Indian standards before and after the supplementation study

Group	Mean height (cm)				Average increase in height (cm)		*Indian standards (cm)		Reduction from the standard (cm)				't' value	
	Boys		Girls						Boys		Girls			
	BS	AS	BS	AS	Boys	Girls	Boys	Girls	BS	AS	BS	AS	Boys	Girls
Control (n=40)	145.18	146.75	138.93	139.62	1.57	0.69	160.66	154.82	15.48	13.91	15.89	15.20	10.43**	5.87**
2/3rd RDA (n=40)	145.45	146.97	143.08	143.96	1.52	0.88	160.66	154.82	15.21	13.69	11.74	10.86	9.95**	8.22**
Full RDA (n=40)	141.24	143.32	142.78	143.18	2.08	1.40	160.66	154.82	19.42	17.34	13.04	11.64	14.64**	2.58**

BS - Before supplementation; AS - After supplementation; *ICMR (1990); ** Significant at 1% level

4.4 Effect of feeding amaranth on the health and nutritional status of adolescents

Nutritional status of adolescents was assessed by anthropometric measurements, clinical examination and haematological indices before and after the supplementary feeding trial with amaranth. The actual food and nutrient intake of adolescents was assessed during the study period.

4.4.1 Anthropometric measurements

Anthropometric measurements namely height and weight of adolescent boys and girls in all the three groups were measured and compared with the Indian standards and classified according to the grades of malnutrition before and after the supplementation study. The results are furnished below.

4.4.1.1 Height for age

The mean height of adolescent boys and girls before and after the supplementary feeding trial in comparison with the Indian standards (ICMR, 1990) and its statistical interpretations are given in Table 5.

From the table it is seen that the mean height of adolescent boys and girls were increased in all the three groups after the supplementation study. An increase of 1.57 cm and 0.69 cm was recorded among boys and girls respectively in the control group. The 2/3rd RDA and full RDA groups of adolescent boys showed an increment of 1.52 cm and 2.08 cm respectively and in adolescent girls the increase in height was 0.88 cm and 1.4 cm respectively in the two experimental groups.

When the height before and after the supplementation study were compared with Indian standards, it is observed that the height of adolescent boys and girls in the three groups were below the standard height suggested by ICMR (1990).

Table 6. Comparison of mean weight of adolescents with the Indian standards before and after the supplementation study

Group	Mean weight (kg)				Average increase in weight (kg)		*Indian standards (kg)		Reduction from the standard (kg)				't' value	
	Boys		Girls						Boys		Girls			
	BS	AS	BS	AS	Boys	Girls	Boys	Girls	BS	AS	BS	AS	Boys	Girls
Control (n=40)	36.39	37.49	31.20	31.67	1.1	0.47	47.88	46.66	11.49	10.39	15.46	14.99	8.48**	7.72**
2/3rd RDA (n=40)	35.68	36.93	33.11	33.63	1.25	0.52	47.88	46.66	12.20	10.95	13.55	13.03	7.49**	7.30**
Full RDA (n=40)	32.06	34.29	33.55	34.36	2.23	0.81	47.88	46.66	15.82	13.59	13.11	12.30	4.45**	7.51**

BS - Before supplementation; AS - After supplementation; *ICMR (1990); ** Significant at 1% level

Statistical analysis of the data revealed that the increments in the mean height after the study was statistically significant in all the three groups.

Analysis of variance (Appendix-VI) was done to compare the mean height of three groups and the results indicated that in the case of boys significant difference was observed among 2/3rd RDA and full RDA group. The difference between control and 2/3rd RDA group was not significant. In girls, the difference existed among the three groups after the study period was not significant with regard to height.

4.4.1.2 Weight for age

The mean weight of adolescent boys and girls before and after the supplementation study in comparison with the Indian standards (ICMR, 1990) and its statistical interpretations are given in Table 6.

From the table it is clear that the mean body weight of adolescent boys and girls were increased in all the three groups after the supplementation study. An increase of 1.1 kg and 0.47 kg was reported among boys and girls respectively in the control group. 2/3rd RDA and full RDA group of adolescent boys showed an increment of 1.25 kg and 2.23 kg respectively and in adolescent girls the increase in body weight was 0.52 kg and 0.81 kg respectively.

When the mean body weights before and after the supplementation study were compared with the Indian standards, it is observed that the weight of adolescent boys and girls in the three groups were below the standards suggested by ICMR (1990).

Statistical analysis of the data revealed that the increments in the mean body weight after the study was statistically significant in all the three groups.

Analysis of variance (Appendix-VI) was done to compare the mean body weights of three groups and indicated that in the case of boys and girls

Table 7. Distribution of adolescents (13-15 years) based on weight for height (Waterlow, 1972)

Nutritional status	Weight for height ratio	Control group						2/3rd RDA						Full RDA					
		BS			AS			BS			AS			BS			AS		
		B	G	T	B	G	T	B	G	T	B	G	T	B	G	T	B	G	T
Severe malnutrition	<75%	4 (20)	11 (55)	15 (37.5)	4 (20)	11 (55)	15 (37.5)	6 (30)	10 (50)	16 (40)	4 (20)	9 (45)	13 (32.5)	12 (60)	10 (50)	22 (55)	7 (35)	9 (45)	16 (40)
Moderate malnutrition	75-84%	10 (50)	7 (35)	17 (42.5)	8 (40)	7 (35)	15 (37.5)	7 (35)	8 (40)	15 (37.5)	9 (45)	9 (45)	18 (45)	7 (35)	6 (30)	13 (32.5)	9 (45)	7 (35)	16 (40)
Marginal malnutrition	85-90%	-	2 (10)	2 (5)	3 (15)	2 (10)	5 (12.5)	2 (10)	1 (5)	3 (7.5)	1 (5)	1 (5)	2 (5)	1 (5)	2 (10)	3 (7.5)	2 (10)	2 (10)	4 (10)
Normal	>90%	6 (30)	-	6 (15)	5 (25)	-	5 (12.5)	5 (25)	1 (5)	6 (15)	6 (30)	1 (5)	7 (17.5)	-	2 (10)	2 (5)	2 (10)	2 (10)	4 (10)
Total		20 (100)	20 (100)	40 (100)	20 (100)	20 (100)	40 (100)	20 (100)	20 (100)	40 (100)	20 (100)	20 (100)	40 (100)	20 (100)	20 (100)	40 (100)	20 (100)	20 (100)	40 (100)

BS - Before supplementation
AS - After supplementation

B - Boys
G - Girls
T - Total

Number in parentheses are percentage

significant difference was observed among 2/3rd RDA and full RDA and among control group and full RDA group after the study period. The difference between control group and 2/3rd RDA group was not significant with regard to body weight.

4.4.1.3 Weight for height

The nutritional status of adolescents before and after the supplementation study was graded based on their weight for height as suggested by Waterlow (1972).

The results (Table 7) revealed that the percentage of adolescents with severe malnutrition decreased by 7.5 per cent and 15 per cent in 2/3rd RDA and full RDA groups respectively whereas in the control group, the percentage remained same (37.5%) before and after the study. An increase of 7.5 per cent was observed in adolescents with moderate malnutrition in 2/3rd and full RDA groups but in the control group, 5 per cent decrease was observed in the percentage of adolescents with moderate malnutrition after the study period.

The percentage of adolescents with marginal malnutrition showed an increase of 7.5 per cent and 2.5 per cent in control and full RDA group respectively, but in 2/3rd RDA group the percentage of adolescents decreased by 2.5 percent after the supplementation study. An increase in the percentage of adolescents with normal nutritional status was observed in 2/3rd and full RDA groups by 2.5 per cent and 5 per cent respectively whereas a decrease in the percentage by 2.5 per cent was observed in control group of adolescents after the study period (Fig.1).

4.4.1.4 Body mass index (BMI)

Based on the BMI, the adolescent boys and girls in the control, 2/3rd RDA and full RDA groups before and after the supplementation study were categorized in to different grades of malnutrition and are furnished in Table 8.

Table 8. Distribution of adolescents (13-15 years) based on Body Mass Index (BMI) (James *et al.*, 1988)

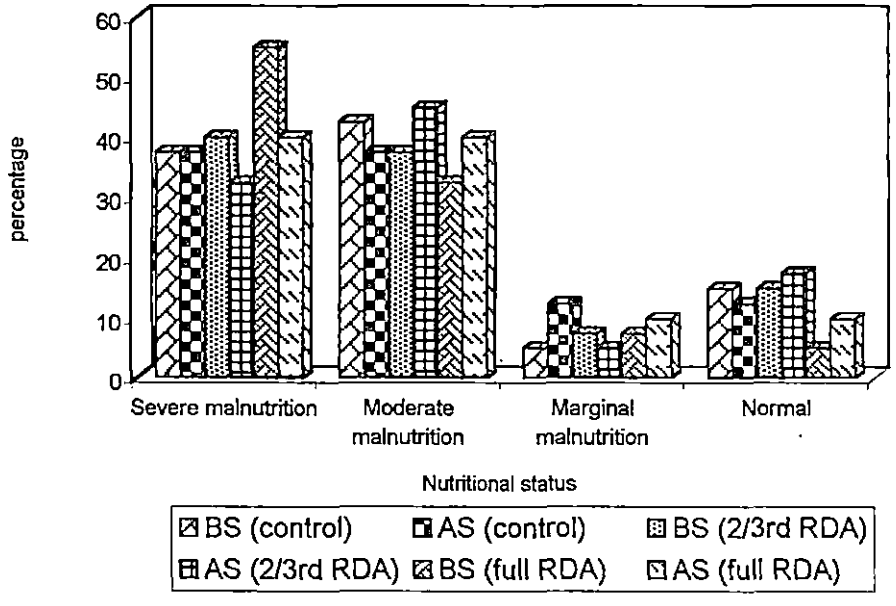
BMI Class	Presumptive diagnosis	Control group						2/3rd RDA						Full RDA					
		BS			AS			BS			AS			BS			AS		
		B	G	T	B	G	T	B	G	T	B	G	T	B	G	T	B	G	T
<16	CED grade III severe	5 (25)	9 (45)	14 (35)	4 (20)	10 (50)	14 (35)	8 (40)	9 (45)	17 (42.5)	8 (40)	8 (40)	16 (40)	10 (50)	5 (25)	15 (37.5)	8 (40)	7 (35)	15 (37.5)
16.0-17.0	CED grade II moderate	3 (15)	7 (35)	10 (25)	4 (20)	5 (25)	9 (22.5)	4 (20)	5 (25)	9 (22.5)	3 (15)	4 (20)	7 (17.5)	4 (20)	9 (45)	13 (32.5)	5 (25)	6 (30)	11 (27.5)
17.0-18.5	CED grade I mild	10 (50)	2 (10)	12 (30)	9 (45)	3 (15)	12 (30)	4 (20)	5 (25)	9 (22.5)	4 (20)	7 (35)	11 (27.5)	4 (20)	3 (15)	7 (17.5)	4 (20)	4 (20)	8 (20)
18.5-20.0	Low weight normal	1 (5)	2 (10)	3 (7.5)	2 (10)	2 (10)	4 (10)	3 (15)	1 (5)	4 (10)	4 (20)	1 (5)	5 (12.5)	2 (10)	3 (15)	5 (12.5)	3 (15)	3 (15)	6 (15)
20.0-25.0	Normal	1 (5)	-	1 (2.5)	1 (5)	-	1 (2.5)	1 (5)	-	1 (2.5)	1 (5)	-	1 (2.5)	-	-	-	-	-	-
25.0-30.0	Obese grade I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
>30.0	Obese grade II	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total		20 (100)	20 (100)	40 (100)	20 (100)	20 (100)	40 (100)	20 (100)	20 (100)	40 (100)	20 (100)	20 (100)	40 (100)	20 (100)	20 (100)	40 (100)	20 (100)	20 (100)	40 (100)

BS - Before supplementation
AS - After supplementation

B - Boys
G - Girls
T - Total

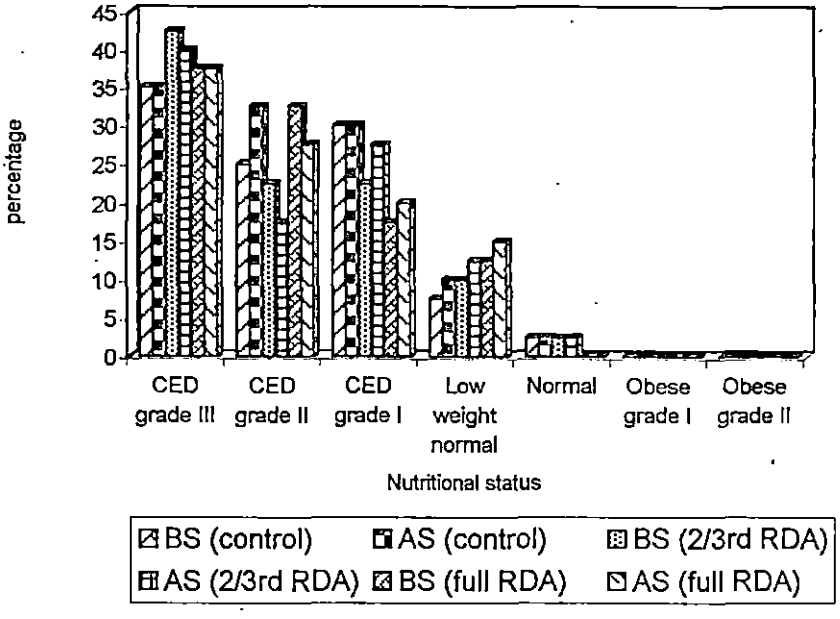
Number in parentheses are percentage

Fig. 1. Percentage distribution of adolescents based on weight for height before and after the supplementation study



BS - Before supplementation
AS - After supplementation

Fig. 2. Percentage distribution of adolescents based on body mass index (BMI) before and after the supplementation study



BS - Before supplementation
AS - After supplementation

The results indicated that in 2/3rd RDA group the adolescents with chronic energy deficiency (CED) grade III showed a decrease of 2.5 per cent after supplementing the diet with amaranth whereas in the other two groups, the percentage remained the same. A decrease in the percentage of adolescents with CED grade II was observed in all the three groups with a greater decrease in 2/3rd (5.0%) and full RDA (5.0%) groups.

The percentage of adolescents with CED grade I malnutrition before and after the study remained same in the control group but in 2/3rd RDA and full RDA groups, the percentage increased from 22.5 to 27.5 percent and 17.5 to 20 per cent respectively. The percentage of adolescents with low weight-normal nutritional status was increased in all the three groups by 5 per cent.

None of the adolescents in the full RDA group had normal nutritional status before and after the supplementation study whereas in control and 2/3rd RDA groups, the percentage of adolescents with normal nutritional status remained same before and after the study period. None of the adolescents in all the three groups were included in obese grade I and grade II nutritional status before and after the study (Fig.2).

4.4.2 Food and nutrient intake

The actual food intake of adolescent boys and girls were assessed by one day food weighment method and the quantity of each food item was compared with the quantity specified for a balanced diet suggested by ICMR (1984) and the results are furnished in Table 9.

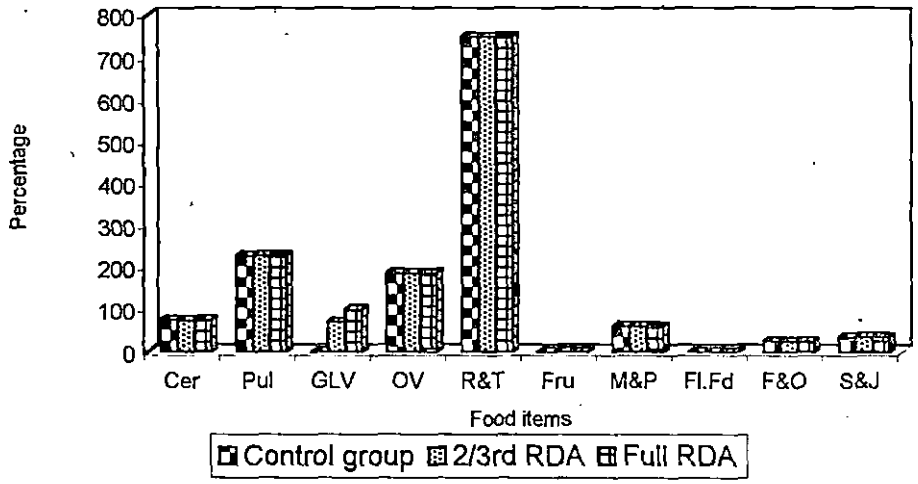
The results indicated that the mean intake of cereals, milk and milk products, fats and oils, sugar and jaggery were lower than the recommended allowances in all the three groups. The consumption of pulses and other vegetables among adolescent boys and girls in all the three groups were found to be higher than the RDA. Green leafy vegetables was not included in the diet of control

Table 9. Mean food intake of adolescents in comparison with RDA

Food items	RDA (g)		Mean food inake (g)					
			Control group		2/3rd RDA		Full RDA	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Cereals	450	440	336 (74.67)	390 (88.64)	334 (74.2)	390 (88.64)	336 (74.67)	390 (88.64)
Pulses	35	25	80 (228.57)	30 (120)	80 (228.57)	30 (120)	80 (228.57)	30 (120)
Green leafy vegetables	50	125	-	-	35 (70)	85 (68)	50 (100)	125 (100)
Other vegetables	70	75	130 (185.71)	110 (146.67)	130 (185.71)	110 (146.67)	130 (185.71)	110 (146.67)
Roots and tubers	40	50	300 (750)	30 (60)	300 (750)	30 (60)	300 (750)	30 (60)
Fruits	30	30	-	15 (50)	-	15 (50)	-	15 (50)
Milk and milk products	250	250	150 (60)	175 (70)	150 (60)	175 (70)	150 (60)	175 (70)
Fleshy foods	45	40	-	30 (75)	-	30 (75)	-	30 (75)
Fats and oil	60	60	15 (25)	20 (33.3)	15 (25)	20 (33.3)	15 (25)	20 (33.3)
Sugar and jaggery	45	40	16 (35.56)	25 (62.5)	16 (35.56)	25 (62.5)	16 (35.56)	25 (62.5)

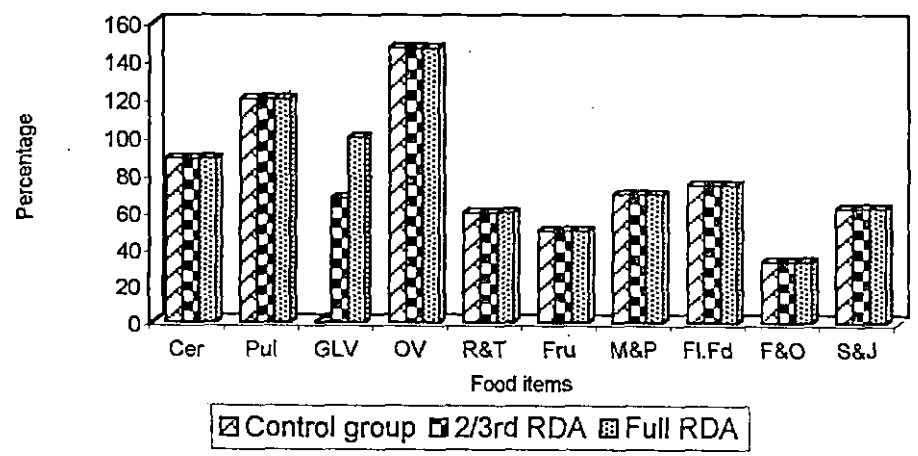
Number in parentheses are percentage

Fig. 3. Food intake of adolescent boys as percentage of RDA



Cer - Cereals
Pul - Pulses
GLV - Green Leafy Vegetables
OV - Other vegetables
RT - Roots and Tubers
Fru - Fruits
M & P - Milk and Milk products
Fl.Fd - Fleshy foods
F&O - Fats and oils
S&J - Sugar and Jaggery

Fig. 4. Food intake of adolescent girls as percentage of RDA



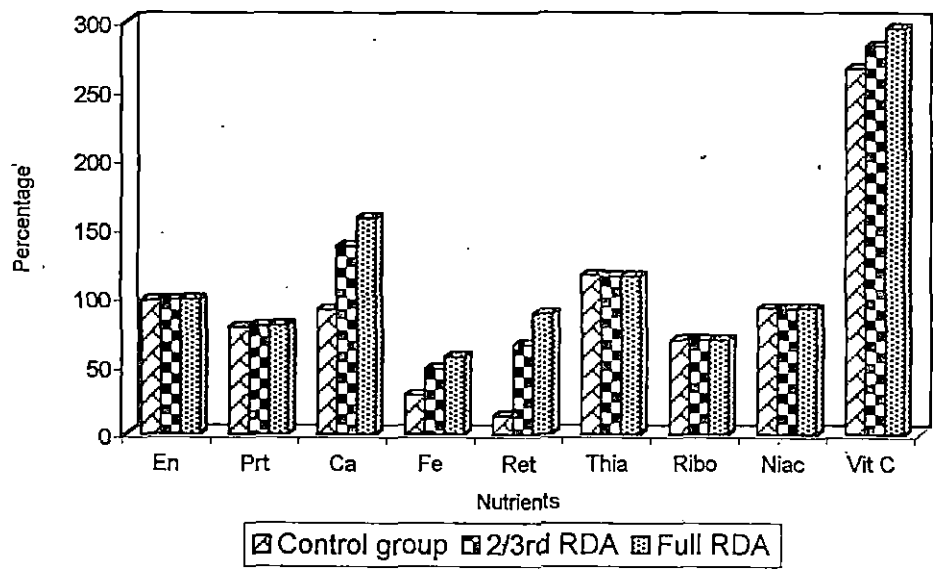
Cer - Cereals
Pul - Pulses
GLV - Green Leafy Vegetables
OV - Other vegetables
RT - Roots and Tubers
Fru - Fruits
M & P - Milk and Milk products
Fl.Fd - Fleshy foods
F&O - Fats and oils
S&J - Sugar and Jaggery

Table 10. Mean nutrient intake of adolescents in comparison with RDA

Nutrients	RDA		Control group		2/3rd RDA		Full RDA	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Energy (Kcal)	2450	2060	2383.78 (97.30)	2082.47 (171.09)	2392.87 (97.67)	2119.02 (102.87)	2407.36 (98.26)	2136.22 (103.7)
Protein (g)	70	65	54.57 (77.96)	45.92 (70.65)	55.00 (78.57)	48.47 (74.57)	55.72 (79.26)	49.06 (75.48)
Calcium (mg)	600	600	543.35 (90.56)	425.63 (70.94)	823.03 (137.17)	1105.63 (184.27)	943.45 (157.24)	1425.63 (237.61)
Iron (mg)	51	28	11.79 (28.76)	11.11 (39.68)	19.77 (48.22)	30.58 (109.21)	23.25 (56.71)	39.34 (140.5)
Retinol (mcg)	600	600	80.10 (13.35)	145.32 (24.22)	391.95 (65.33)	902.67 (150.45)	525.60 (87.6)	1259.07 (209.85)
Thiamine (mg)	1.2	1.0	1.39 (115.83)	1.29 (129)	1.38 (115)	1.29 (129)	1.38 (115)	1.29 (129)
Riboflavin (mg)	1.5	1.2	1.03 (68.67)	0.85 (70.83)	1.03 (68.67)	0.85 (70.83)	1.03 (68.67)	0..85 (70.83)
Niacin (mg)	16	14	14.69 (91.87)	17.06 (121.86)	14.68 (91.75)	17.06 (121.86)	14.70 (91.88)	17.06 (121.86)
Vitamin C (mg)	40	40	106.40 (266)	28.65 (71.63)	112.90 (282.25)	56.70 (141.75)	117.95 (294.88)	69.90 (174.75)

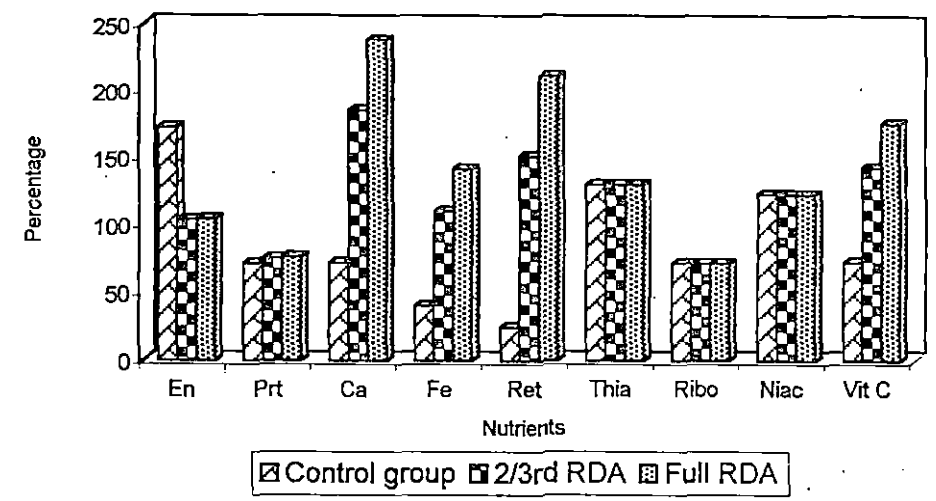
Number in parentheses are percentage

Fig. 5. Nutrient intake of adolescent boys as percentage of RDA



En - Energy
Prt - Protein
Ca - Calcium
Fe - Iron
Ret - Retinol
Thia - Thiamine
Ribo - Riboflavin
Niac - Niacin
Vit C - Vitamin C

Fig. 6. Nutrient intake of adolescent girls as percentage of RDA



En - Energy
Prt - Protein
Ca - Calcium
Fe - Iron
Ret - Retinol
Thia - Thiamine
Ribo - Riboflavin
Niac - Niacin
Vit C - Vitamin C

group, where as it was included in the diet of other two groups to meet 2/3rd and full RDA. Among boys, the intake of roots and tubers was found to be higher than RDA (300 g), but in girls, intake was lower than the RDA. Fruits and non-vegetarian foods were not included in the diet of adolescent boys, but in adolescent girls 50 per cent and 75 per cent of the RDA was met in case of fruits and non vegetarian foods respectively (Fig.3 and 4).

The nutrients present in the diet of adolescent boys and girls were calculated from the quantity of food consumed using food composition table. The results were compared with 1989 Recommended Dietary Allowances (RDA) of nutrients suggested by ICMR (1990) and the results are given in Table 10.

The mean nutrient intake of adolescent boys in the control group revealed that except thiamine and vitamin C, the intake of all other nutrients were lower than the recommended levels. In 2/3rd and full RDA group of boys, the calcium, thiamine and vitamin C intake was found to be higher than the RDA and the intake of other nutrients were lower than the recommended levels. In the case of adolescent girls, energy, thiamine and niacin intake was found to be higher than RDA. The 2/3rd and full RDA group of adolescent girls also showed a higher intake of calcium, iron and retinol compared with recommended levels and intake of all other nutrients were found to be lower than recommended values in all the three groups (Fig.5 and 6).

4.4.3 Clinical examination of adolescents

The adolescent boys and girls were clinically examined for manifestation of any clinical symptoms before and after the study. The results are tabulated in Table 11.

From the table it is clear that before the supplementation study, 30 per cent of adolescents in the control and 2/3rd RDA group and 31 per cent of adolescents in the full RDA group manifested clinical symptoms but after the

Table 11. Manifestation of clinical symptoms before and after the study.

Presence of clinical symptom	Control group						2/3rd RDA						Full RDA					
	BS			AS			BS			AS			BS			AS		
	B	G	T	B	G	T	B	G	T	B	G	T	B	G	T	B	G	T
Present	14 (70)	16 (80)	30 (75)	14 (70)	13 (65)	27 (67.5)	16 (80)	14 (70)	30 (75)	12 (60)	12 (60)	24 (60)	14 (70)	17 (85)	31 (77.5)	9 (45)	10 (50)	19 (47.5)
Absent	6 (30)	4 (20)	10 (25)	6 (30)	7 (35)	13 (32.5)	4 (20)	6 (30)	10 (25)	8 (40)	8 (40)	16 (40)	6 (30)	3 (15)	9 (22.5)	11 (55)	10 (50)	21 (52.5)
Total	20 (100)	20 (100)	40 (100)	20 (100)	20 (100)	40 (100)	20 (100)	20 (100)	40 (100)	20 (100)	20 (100)	40 (100)	20 (100)	20 (100)	40 (100)	20 (100)	20 (100)	40 (100)
Type of clinical symptom Bitot's spot	1	-	1	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Phryno derma	1	2	3	-	2	2	-	2	2	-	-	-	-	-	-	-	-	-
Dental caries	6	4	10	9	5	14	5	-	5	6	-	6	8	1	9	9	1	10
Mottled enamel	-	-	-	-	-	-	3	-	3	3	-	3	-	-	-	-	-	-
Koilonychia	1	2	3	-	2	2	-	-	-	-	-	-	-	1	1	-	1	1
Anaemia	13	15	28	12	12	24	16	14	30	11	12	23	14	17	31	8	10	18
Total	14	16	30	14	13	27	16	14	30	12	12	24	14	17	31	9	10	19

BS - Before supplementation
AS - After supplementation

B - Boys
G - Girls
T - Total

Number in parentheses are percentage

supplementation study, the percentage of adolescents with clinical symptoms reduced to 27 per cent, 24 per cent and 19 per cent in control, 2/3rd RDA and full RDA group respectively.

As evident from the table, only dental caries and anaemia were prevalent among adolescents in all the three groups. After the supplementation study, the number of adolescents with dental caries increased in all the three groups, but the number of adolescents with anaemia showed reduction in all the three groups.

Only one adolescent in the control group had bitot's spot, which was also present after the supplementation study. The number of adolescents with phrynoderma showed reduction in control and 2/3rd RDA group after the study. None of the adolescents in full RDA group manifested Phrynoderma before and after the study. The condition of mottled enamel was present only in 2/3rd RDA group of adolescents before and after the study. Koilonychia was also present among adolescents in control and full RDA group before and after the supplementation study.

4.4.4 Haematological indices

Table 12 furnishes the results of the biochemical estimation of blood of the adolescent boys and girls for haemoglobin, red blood cell count and packed cell volume before and after the supplementary feeding trial with amaranth.

From the table it is seen that the haematological indices showed increments in all the three groups. Taking into consideration the haemoglobin values, the control group of adolescent boys and girls showed an increase of 0.09 g/100 ml and 0.18 g/100 ml respectively. 2/3rd RDA and full RDA group of adolescent boys showed an increment of 0.39 g/100 ml and 0.93 g/100 ml respectively and in adolescent girls the increase in haemoglobin level was 0.60 g/100 ml and 1.0 g/100 ml respectively. The statistical analysis of the data

Table 12. Mean haematological indices of adolescents before and after the supplementation study

	Control group								2/3rd RDA group							
	BS		AS		Average increase		't' value		BS		AS		Average increase		't' value	
	B	G	B	G	B	G	B	G	B	G	B	G	B	G	B	G
Haemoglobin (g/100 ml)	9.26	9.98	9.35	10.16	0.09	0.18	4.51**	5.97**	9.46	9.40	9.85	10.00	0.39	0.60	6.84**	8.10**
RBC count (million/cmm)	3.21	3.31	3.25	3.47	0.04	0.16	1.71^{NS}	6.05**	3.18	2.91	3.41	3.36	0.23	0.45	6.96**	10.76**
Packed cell volume (per cent)	29.66	30.24	29.78	31.01	0.12	0.77	2.08*	4.45**	28.56	28.86	29.57	30.75	1.01	1.89	5.79**	4.54**

	Full RDA group							
	BS		AS		Average increase		't' value	
	B	G	B	G	B	G	B	G
Haemoglobin (g/100 ml)	9.44	9.21	10.37	10.21	0.93	1.0	11.28**	11.37**
RBC count (million/cmm)	3.17	2.93	3.56	3.47	0.39	0.54	12.03**	9.66**
Packed cell volume (per cent)	29.03	28.30	31.44	30.75	2.41	2.45	7.20**	7.08**

BS – Before Supplementation
AS – After Supplementation

B - Boys
G- Girls

NS – Non Significant
* Significant at 5% level
** Significant at 1% level

revealed that the increments in the mean haemoglobin levels after the study was statistically significant in all the three groups.

The RBC count showed an increase of 0.04 million/cmm and 0.16 million/cmm in the control group adolescent boys and girls respectively. The 2/3rd RDA and full RDA group of adolescent boys showed an increment of 0.23 million/cmm and 0.39 million/cmm respectively and in adolescent girls the increase in RBC count was 0.45 million/cmm and 0.54 million/cmm respectively. The statistical analysis of the data revealed that the increase in mean RBC count was non significant in adolescent boys of control group. In all others the increments in the mean RBC count after the study was significant at 1 per cent level.

The control group of adolescent boys and girls showed an increase of 0.12 per cent and 0.77 per cent respectively in the case of packed cell volume. 2/3rd RDA and full RDA group of adolescent boys showed an increment of 1.01 per cent and 2.41 per cent respectively and in adolescent girls the increase in pcv was 1.89 per cent and 2.45 per cent respectively. Statistical analysis of the data ('t' value) revealed that the increments in the mean packed cell volume after the supplementation study among adolescent boys of the control group was significant only at 5 per cent level where as in all others, it was significant at 1 per cent level.

The haemoglobin values of adolescent boys and girls before and after the study was compared with the standard values suggested by WHO as given by Gopaldas and Seshadri (1987) and the results are given in Table 13.

From the table it is revealed that none of the adolescent boys and girls were included either in the deficient (<8 g/dl) and in the normal (>12 g/dl) level of haemoglobin before and after the supplementary feeding trial. The percentage of adolescents with haemoglobin level ranging between 8-10 g/dl showed 2.5 per cent, 7.5 per cent and 37.5 per cent decline in the case of control 2/3rd RDA and

Table 13. Distribution of adolescents (13-15 years) based on haemoglobin level before and after the study

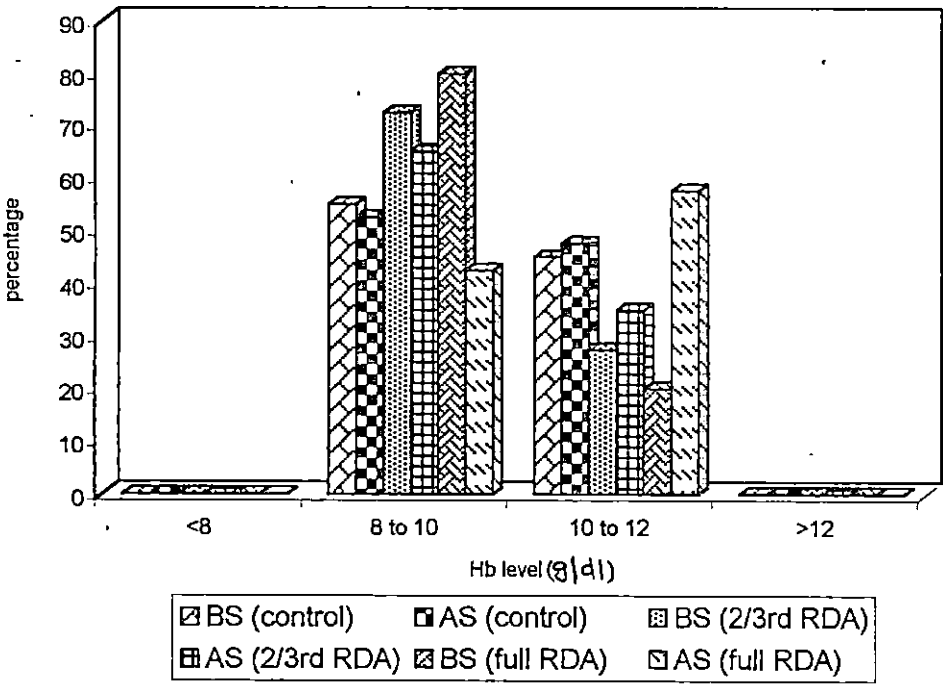
Hb level g/dl	Presumptive diagnosis	Control group						2/3rd RDA						Full RDA					
		BS			AS			BS			AS			BS			AS		
		B	G	T	B	G	T	B	G	T	B	G	T	B	G	T	B	G	T
<8	Deficient	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8-10	Low	11 (55)	11 (55)	22 (55)	11 (55)	10 (50)	21 (52.5)	15 (75)	14 (70)	29 (72.5)	14 (70)	12 (60)	26 (65)	15 (75)	17 (85)	32 (80)	7 (35)	10 (50)	17 (42.5)
10-12	Low	9 (45)	9 (45)	18 (45)	9 (45)	10 (50)	19 (47.5)	5 (25)	6 (30)	11 (27.5)	6 (30)	8 (40)	14 (35)	5 (25)	3 (15)	8 (20)	13 (65)	10 (50)	23 (57.5)
>12	Acceptable	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total		20 (100)	20 (100)	40 (100)	20 (100)	20 (100)	40 (100)	20 (100)	20 (100)	40 (100)	20 (100)	20 (100)	40 (100)	20 (100)	20 (100)	40 (100)	20 (100)	20 (100)	40 (100)

BS - Before supplementation
AS - After supplementation

B - Boys
G - Girls
T - Total

Number in parentheses are percentage

Fig. 7. Percentage distribution of adolescents based on haemoglobin level before and after the supplementation study



BS - Before supplementation
AS - After supplementation

Table 14. RBC count and PCV of adolescents in comparison with normal values

Haematological indices	Control group						2/3rd RDA						Full RDA					
	BS			AS			BS			AS			BS			AS		
	B	G	T	B	G	T	B	G	T	B	G	T	B	G	T	B	G	T
RBC count million/cmm Normal Boys >5 Girls >4.3	-	-	-	-	1 (5)	1 (2.5)	-	-	-	-	1 (5)	1 (2.5)	-	-	-	-	2 (10)	2 (5)
Below Normal	20 (100)	20 (100)	40 (100)	20 (100)	19 (95)	39 (97.5)	20 (100)	20 (100)	40 (100)	20 (100)	19 (95)	39 (97.5)	29 (100)	20 (100)	40 (400)	20 (100)	18 (90)	38 (95)
Total	20 (100)	20 (100)	40 (100)	20 (100)	20 (100)	40 (100)	20 (100)	20 (100)	40 (100)	20 (100)	20 (100)	40 (100)	20 (100)	20 (100)	40 (100)	20 (100)	20 (100)	40 (100)
PCV Normal Boys ≥ 40 Girls ≥ 35	-	-	-	-	1 (5)	1 (2.5)	-	-	-	-	1 (5)	1 (2.5)	-	-	-	-	2 (10)	2 (5)
Below Normal	20 (100)	20 (100)	40 (100)	20 (100)	19 (95)	39 (97.5)	20 (100)	20 (100)	40 (100)	20 (100)	19 (95)	39 (97.5)	20 (100)	20 (100)	40 (100)	20 (100)	18 (90)	38 (95)
Total	20 (100)	20 (100)	40 (100)	20 (100)	20 (100)	40 (100)	20 (100)	20 (100)	40 (100)	20 (100)	20 (100)	40 (100)	20 (100)	20 (100)	40 (100)	20 (100)	20 (100)	40 (100)

BS - Before supplementation
AS - After supplementation

B - Boys
G - Girls
T - Total

Number in parentheses are percentage

full RDA group respectively after the supplementation study. Whereas the percentage of adolescents with haemoglobin level ranging between 10-12 g/dl showed increase after the study period. The increment showed by control group was 2.5 per cent and 2/3rd RDA and full RDA group showed 7.5 per cent and 37.5 per cent respectively (Fig.7).

Analysis of variance (Appendix-VI) was done to compare the mean haemoglobin values of three groups and indicated that in the case of adolescent boys, significant difference was observed among the three groups after the study period. In girls the difference between control and 2/3rd RDA group and 2/3rd RDA and full RDA group was significant. The difference existed between control and full RDA group was not significant with regard to haemoglobin levels.

The RBC count and packed cell volume of adolescents before and after the study were compared with the normal values and the results are furnished in Table 14.

From the table it is seen that adolescents in all the three groups were below normal with regard to RBC count and pcv before the study period. After the study period, 2.5 per cent, 2.5 per cent and 5 per cent of the adolescents in the control, 2/3rd RDA and full RDA group respectively became normal.

Analysis of variance (Appendix-VI) was done to compare the means of three groups and revealed that among boys significant difference was observed between the 3 groups in the case of RBC count and pcv. In girls significant difference was observed among control and full RDA group in the case of RBC count. The difference between control and 2/3rd RDA group and 2/3rd RDA and full RDA group was not significant with regard to RBC count, where as the pcv values showed significant difference between the three groups.

Table 15. Mean scores for the functional performance of adolescents before and after the study

Group	Mean scores for functional performance				Average increase in mean score		't' Value	
	Boys		Girls					
	BS	AS	BS	AS	Boys	Girls	Boys	Girls
Control (n=40)	55.91	56.35	53.80	55.22	0.44	1.42	3.92**	2.14*
2/3rd RDA (n=40)	52.55	56.61	50.48	57.17	4.06	6.69	10.03**	9.15**
Full RDA (n=40)	51.04	60.38	49.11	59.11	9.34	10.0	14.45**	10.66**

BS – Before Supplementation
AS – After Supplementation

* Significant at 5% level
** Significant at 1% level

4.5 Effect of feeding amaranth on the functional performance of adolescents

Table 15 furnishes the results of the functional performance test conducted among the adolescent boys and girls before and after the supplementation study.

The mean scores obtained for the functional performance test showed an increase in all the groups after the supplementation study. The control group of adolescent boys and girls showed an increase of 0.44 and 1.42 respectively. The 2/3rd RDA and full RDA group of adolescent boys showed an increment of 4.06 and 9.34 respectively and in girls the mean score increment was found to be 6.69 and 10.0 respectively. Statistical analysis of the data revealed that the increments in the mean scores of functional performance after the study was statistically significant in all the three groups.

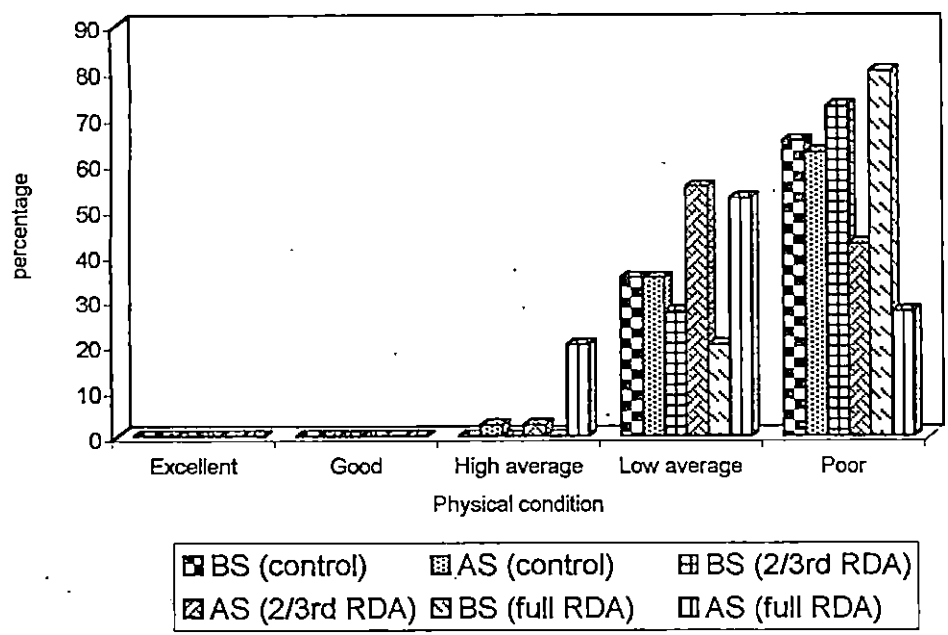
The adolescents in the three groups were categorized into different physical conditions (Brouha, 1943) based on the mean score obtained in the functional performance test and the results are furnished in Table 16.

The table revealed that none of the adolescents had excellent and good physical condition before and after the supplementation study. High average physical condition was not present in adolescents before the study but after the supplementation study, 2.5 per cent of adolescents in the control group, 2.5 per cent of adolescents in 2/3rd RDA group and 20 per cent of adolescents in the full RDA group showed high average physical condition in the functional performance test (index between 65-79). The percentage of adolescents with low average physical condition remained same in the control group before and after the study period whereas in 2/3rd RDA and full RDA group, the percentage increased from 27.5 per cent to 55 per cent and 20 per cent to 52.5 per cent respectively. A decrease in the percentage of adolescents with poor physical condition was observed in all the three groups after the supplementation study (Fig.8).

Table 16. Distribution of adolescents (13-15 years) based on functional performance (Brouha, 1943).

Index	Physical condition	Control group						2/3rd RDA						Full RDA					
		BS			AS			BS			AS			BS			AS		
		B	G	T	B	G	T	B	G	T	B	G	T	B	G	T	B	G	T
Above 90	Excellent	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
80-89	Good	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
65-79	High average	-	-	-	1 (5)	-	1 (2.5)	-	-	-	-	1 (5)	1 (2.5)	-	-	-	5 (25)	3 (15)	8 (20)
55-64	Low average	5 (25)	9 (45)	14 (35)	3 (15)	11 (55)	14 (35)	6 (30)	5 (25)	11 (27.5)	10 (50)	12 (60)	22 (55)	5 (25)	3 (15)	8 (20)	9 (45)	12 (60)	21 (52.5)
Below 55	Poor	15 (75)	11 (55)	26 (65)	16 (80)	9 (45)	25 (62.5)	14 (70)	15 (75)	29 (72.5)	10 (50)	7 (35)	17 (42.5)	15 (75)	17 (85)	32 (80)	6 (30)	5 (25)	11 (27.5)
Total		20 (100)	20 (100)	40 (100)	20 (100)	20 (100)	40 (100)	20 (100)	20 (100)	40 (100)	20 (100)	20 (100)	40 (100)	20 (100)	20 (100)	40 (100)	20 (100)	20 (100)	40 (100)

Fig. 8. Percentage distribution of adolescents into various physical conditions based on functional performance before and after the supplementation study



BS - Before supplementation
AS - After supplementation

Analysis of variance (Appendix-VI) was done to compare the means of three groups and indicated that in the case of adolescent boys and girls significant difference was observed among the three groups after the study period.

DISCUSSION

DISCUSSION

The present study was carried out to find out the effect of amaranth on the health and nutritional profile of adolescents. This chapter presents a critical discussion on the major findings and the details are presented under the following broad sections.

5.1 Food consumption pattern of the inmates in the institutions
5.2 Organoleptic qualities of amaranth recipes
5.3 Nutrient composition of fresh amaranth and amaranth recipes
5.4 Effect of feeding amaranth on the health and nutritional status of adolescents
5.5 Effect of feeding amaranth on the functional performance of adolescents

5.1 Food consumption pattern of the inmates of the institutions

Precise information on the food consumption pattern of people is essential not only for assessing the nutritional status of the community but also for elucidating the food needs of population groups at national and regional levels (Thimmayamma and Rau, 1996).

Food consumption pattern in the institutions indicated that all the inmates were habitually non-vegetarians and the staple food consumed was cereals especially rice.

The economic status of the institution is an important factor which may influence the frequency of use of various foods. The inmates of both institutions used cereals, vegetables, milk, fats and oils, sugar and spices on a daily basis. The other daily used items by the inmates of institution I included pulses and roots and tubers, where as in institution II, these items were used weekly twice and weekly thrice respectively. Green leafy vegetables, fruits and jaggery were occasionally used in both the institutions. Fish, meat and egg were used by the inmates of

institution I weekly once and monthly twice respectively, but in institution II, they used these items weekly twice, occasionally and weekly once respectively.

In both institutions, they maintained accounts for income and expenditure on a daily basis in written form. An accountant each was employed in both the institutions, hence the accounts procedures were routinely followed and were up to date.

Advanced meal planning was done in both the institutions. This advanced meal planning helps in better organisation and faster completion of institutional chores. Meal planning was based on food availability in institution I and money availability in institution II.

Meal planning in the institutions indirectly indicate the dietary habits. Analysis of the meal pattern in the institutions indicated that three meals a day was common in both institutions. Institution I and II maintained a routine schedule for consuming meals. It was observed that in both places they gave equal importance to all inmates with regard to food distribution.

Regarding cooking methods followed, both institutions used boiling and straining for cooking cereals. Boiling method was followed for most of the food items by both institutions. Green leafy vegetables was cooked by absorption method. Fruits were eaten after steaming by institution II especially in the case of bananas.

Cooking was done three times a day in both institutions. In institution I cooking was done by cook with the help of inmates and in institution II it was done by cook and assistants. Ordinary chullah was used by institution I for cooking purposes. In addition to ordinary chullah institution II used LPG stove for cooking purposes. The inmates of institution II used boiled water for drinking purposes where as, in institution I they used water without boiling for drinking.

Preservation of foods mainly mango, lime and gooseberries after salting and pickling was common in both the institutions.

Diet was modified during illness in both institutions. Liquid foods were preferred to the solid diet. Kanji, pickle pappad, black tea or coffee rusk bread were mostly consumed during illness.

Special foods like payasam and non-vegetarian dishes were prepared in both institutions on special occasions.

5.2 Organoleptic qualities of amaranth recipes

The acceptability of amaranth recipes was evaluated using score card. The major qualities studied included appearance, colour, flavour, texture and taste.

In the acceptability study of amaranth recipes the attribute taste had obtained the highest score followed by texture and appearance. The least scores were for flavour and colour. Similar to the findings of this study Alleman *et al.*, (1996) reported that *Amaranthus tricolour* obtained highest scores for taste and texture in their acceptability study. But Neeliyara (1998) observed highest scores for the attribute doneness and least score for texture, when the acceptability of the leaves of winged bean genotypes were analysed.

The results of the acceptability study revealed that all the recipes got a total score higher than 10.

On analysing the scores obtained for different recipes, it can be seen that amaranth in combination with cereals were less acceptable and had obtained total scores varying between 10 and 11 only except for cheera chappathi, which had a higher total score and was selected for feeding trial. While taking into consideration the scores obtained for various quality parameters cheera chappathi scored above 3 for all the quality parameters but the scores for the quality

attributes of other cereal amaranth combinations seemed to be less than 3. Kowsalya and Mohandas (1999) also reported cauliflower leaves incorporated chappathi as an acceptable product.

Amaranth in combination with fish was also not acceptable. However cheera fish curry had a total score of 14.32 and had obtained score above 3 for quality attributes like colour and texture but scored less for taste appearance and flavour. Cheera fish foogath was less acceptable with respect to all quality parameters.

Cheera stew was not that acceptable with respect to total score. Even though it had obtained a better score for texture, the score for taste was lower.

Among cheera curd combinations, pachadi obtained a higher total score. Although cheera curd curry obtained better scores for appearance colour and taste, it scored less for texture and flavour resulting in a lower total score.

From the results it can be seen that cheera pulse combinations were acceptable and had obtained higher total scores.

Cheera jack fruit seed thoran scored better for the quality attributes texture and taste but scored less for other parameters making it moderately acceptable.

Cheera in combination with meat and egg were highly acceptable and cheera minced meat thoran had obtained the highest total score and highest scores for the quality attributes appearance and taste. Cheera egg thoran had obtained a better score for taste but cheera omlette was not that acceptable with respect to appearance and flavour and had obtained a lower total score.

Cheera thoran, cheera curry, cheera cutlet and cheera vada were acceptable in all quality parameters and obtained higher total scores. Kowsalya and

Mohandas (1999) also found that cauliflower leaves were acceptable well in its meal forms viz. curry and thoran as well as in incorporated vada preparation.

Although most of the recipes obtained a higher total score, only ten recipes with the highest total scores were selected for feeding trial.

In general, it can be assumed that amaranth recipes were acceptable with respect to different quality parameters.

5.3 Nutrient composition of fresh amaranth and amaranth recipes

Fresh amaranth and selected amaranth recipes were analysed for important constituents like protein, starch soluble carbohydrate, crude fibre calcium, iron, β-carotene and vitamin C.

The crude protein content of fresh amaranth was 3.34 per cent. This was found to be lower than the values reported by Gopalan *et al.* (1989); NIN (1991a); Prakash *et al.* (1993) (4%); Shingade *et al.* (1995) (5.3%) and Raja *et al.* (1997) (4.94%). Varalakshmi *et al.* (1998) reported that the protein content of amaranth is low but the quality of protein was good.

From the results it is evident that certain preparations showed a higher protein content than fresh amaranth. The preparations which showed higher values for crude protein content were cheera dal maseel, cheera egg thoran, cheera chappathi, cheera vada, cheera minced meat thoran and cheera green gram thoran. Whole wheat flour, pulses, egg and meat were known to contain good quality proteins. These added ingredients could be the reason for increased protein content in these preparations in spite of cooking changes.

The lower protein content observed in cheera thoran and cheera curry may be due to denaturation and alteration of the protein structure. In cheera cutlet, the lowest crude protein content was observed. The ingredient i.e., potato in cheera

cutlet was only a fair source of protein and the denaturation occurred by heating may have caused decrease in the protein content.

Kowsalya and Mohandas (1999) reported lower protein content in cooked samples compared to fresh in cauliflower leaves and concluded that reduction in protein content is due to denaturation occurring while heating.

The starch content of fresh amaranth was 0.20 per cent. This was found to be in accordance with the value reported by Wills *et al.* (1984) (0.2%) and lower than the values reported by John *et al.* (1987) and Gopalan *et al.* (1989) (0.73%).

Results indicated that all the amaranth preparations had higher starch content than fresh amaranth. The preparation cheera chappathi had the highest starch content among the preparations. Whole wheat flour being a rich source carbohydrate, could be the reason for showing a higher value for starch content.

Cheera-pulse combinations also showed higher values for starch content. Cheera cutlet showed higher starch content which may be due to the starch present in potato. Cheera thoran, cheera pachadi, cheera egg thoran, cheera minced meat thoran and cheera curry had lower starch content when compared to other preparations, as the added ingredients in these preparations were lower in starch.

The soluble carbohydrate content of fresh amaranth was 1.68 per cent. According to Shingade *et al.* (1995) the carbohydrate content of *Amaranthus tricolour* is 3.7 per cent which included starch, sugars, fibre and soluble carbohydrate.

The results showed that all preparations had a higher soluble carbohydrate content compared to fresh amaranth.

The increased value of soluble carbohydrate content may be due to the conversion of insoluble form of carbohydrates into soluble form by hydrolysis while cooking.

The crude fibre content of fresh amaranth was 1.72 per cent. The value obtained in this study was lower than the value reported by John *et al.* (1987) (2.3%) and with in the fibre values of 1.3-1.8% reported by Bressani *et al.* (1988) and Shingade *et al.* (1995).

The higher and lower fibre content noticed in amaranth preparation may be due to the added ingredients. Which has got varying fibre content. The lower fibre content observed in preparations might also be due to hydrolysis of fibre particles while cooking.

Kowsalya and Mohandas (1999) reported little changes in fibre content while cooking. In this study also little changes in fibre content was observed in cooked samples.

The calcium content of fresh amaranth was 197.39 mg $100g^{-1}$. The value obtained in this study disagrees with the values reported by Rajagopal *et al.* (1977). Mohideen *et al.* (1985); Menon (1980) and Gopalan *et al.* (1989) (397 mg $100g^{-1}$). Shingade and Chawan (1996) reported that *Amaranthus tricolour* is comparitively high in phosphorus, potassium, calcium, magnesium and micronutrients like iron and boron.

All preparations had lower calcium content than fresh amaranth. This was in accordance with the findings of Kowsalya and Mohandas (1999) who reported that calcium, potassium and copper content of leaves (cauliflower) decreased during cooking.

The fresh amaranth contained 20.52 mg of iron per 100 g. The value observed in this study was lower than the value reported by Menon (1980) (25.5 mg $100g^{-1}$) and much higher than the values reported by Gopalan *et al.* (1989) and NIN (1991a) (3.49 mg $100g^{-1}$).

The iron content of cheera thoran and cheera curry showed slightly higher values when compared with fresh amaranth and in all other preparations

lower values were observed. The result of the study disagrees with the findings of Kowsalya and Mohandas (1999) who observed higher iron content in cooked samples.

The β carotene content of fresh amaranth was 15064 µg $100g^{-1}$. The value obtained in this study disagrees with the reports of Mohideen *et al.* (1995) and Reddy (1999) who reported 6000-9000 µg of β carotene in amaranth.

The β carotene content of recipes were reported to be lower than fresh amaranth. But Koswalya and Mohandas (1999) reported higher β carotene content in cooked samples than fresh ones and concluded that the high β carotene content in cooked samples were due to extraction of fat soluble carotenoids in added fat.

The vitamin C content of fresh amaranth was 136.55 mg $100g^{-1}$. This value was with in the vitamin C values of 120-220 mg $100g^{-1}$ reported by Reddy (1999) and higher than the values reported by Devadas *et al.*, (1973) (96 mg $100g^{-1}$), Mohideen *et al.* (1985) (35.9 mg $100g^{-1}$) and NIN (1991a) (99 mg $100g^{-1}$).

The vitamin C content of preparation were lower than the fresh values. The cooking loss of vitamin C in amaranth preparation seemed to be around 50 per cent Kowsalya and Mohandas (1999) also reported tremendous loss of vitamin C in cooking. Sood and Bhat (1974) reported that the loss of vitamin C in cooking is due to leaching and oxidation of ascorbic acid.

5.4 Effect of feeding amaranth on the health and nutritional status of adolescents

In the present study, anthropometric measurements, clinical examination and haematological indices were used to assess the nutritional status of adolescents before and after the supplementary feeding trial with amaranth. Actual food and nutrient intake of adolescents was assessed during the study period.

5.4.1 Anthropometric measurements

Anthropometric measurements like weight and height were considered as the best tool for detecting various degrees of growth retardation among the population. Even before clinical illness manifests, the growth pattern provide information regarding changes in the nutritional status.

The present study revealed that the weight for age and height for age values of adolescent boys and girls before and after the supplementation study were lower than the national standards suggested by ICMR (1990). NIN (1990b) and Paul (1993) also reported deficit in body height and weight among adolescents. The findings of Nagi *et al.* (1995) disagrees with the findings of this study who reported normal body weight and height among adolescents in Ludhiana city.

The results of the study showed an increase in height and body weight of adolescent boys and girls in all the three groups after the supplementation of amaranth in the diet. On examining the increments, it can be seen that, the highest increase was occurred in full RDA group and higher in 2/3rd RDA group compared to control group. Statistical analysis of the data revealed that the increments in mean height and weight after the study was statistically significant in all the three groups.

Analaysis of variance indicated significant difference between the means of control and full RDA group and 2/3rd and full RDA group (boys and girls) after the study period. The difference between control and 2/3rd RDA was not significant with regard to body weight.

Analysis of variance was done to compare the mean height of three groups and the results indicated that among boys significant difference was observed between 2/3rd and full RDA group and control and full RDA group after the study period but difference existed among control and 2/3rd RDA group was

non significant. In girls, the difference existed among the three groups after the study period was not statistically significant.

The distribution of adolescents based on weight for height suggested by Waterlow (1972) gives the current nutritional status of adolescents. The results indicated that the percentage of adolescents with severe malnutrition decreased in 2/3rd RDA and full RDA groups whereas, in control group the percentage remained same after the study period. An increase in the percentage of adolescents with moderate malnutrition was noticed in 2/3rd and full RDA groups but in control group the percentage decreased after the study. In control and full RDA group an increase in percentage of adolescents with marginal malnutrition was observed but in 2/3rd RDA group, the percentage of adolescents decreased after the supplementation study. The percentage of adolescents with normal nutritional status increased in 2/3rd and full RDA groups whereas, the percentage of adolescents with normal nutritional status showed decrease in control group after the study period. Similar to these results Sarupriya and Mathew (1988) and Kapoor and Aneja (1992) reported different grades of malnutrition among adolescents.

The distribution of adolescents based on body mass index (BMI) revealed that only in 2/3rd RDA group the percentage of adolescents with CED grade III decreased after supplementing the diet with amaranth. The percentage of adolescents with CED grade II showed decrease in all the three groups. In 2/3rd RDA and full RDA groups the percentage of adolescents with CED grade I showed increase and in control group the percentage remained same after the study period. Adolescents with low weight-normal nutritional status showed an increase in all the three groups after the study. The percentage of adolescents with normal nutritional status remained same in control and 2/3rd RDA group after the study period. None of the adolescents in full RDA group was normal before and after the study period. Similar to the findings of this study Chaturvedi *et al.*, (1996) also reported CED of different grades while studying the nutritional status of adolescent girls.

5.4.2 Food and nutrient intake

One day food weighment survey pointed out that the intake of cereals, milk and milk products, fats and oils, sugar and jaggery were lower than the RDA in all the three groups. Similar to the findings of this study, Sarojini and Vijayalakshmi (1989) and Llamas *et al.*, (1996) reported inadequate intake of cereals, milk and milk products and sugar among adolescents. But Sarupriya and Mathew (1988) reported higher intake of cereals among adolescents and higher intake of fat among adolescents was reported by Story and Alton (1996). Intake of pulses and other vegetables among adolescent girls and boys in all the three groups were higher than the RDA. Whereas Sarupriya and Mathew (1988) and Llamas *et al.*, (1996) reported low intake of pulses and vegetables among adolescents. Green leafy vegetables was not included in the diet of control group where as it was included in the diet of other two groups to meet 2/3rd and full RDA. Among boys the intake of roots and tubers was found to be too high compared to RDA and among girls, it was found to be lower than the RDA. Fruit and non vegetarian foods were not included in the diet of adolescent boys but among adolescent girls it was included in the diet and found to be lower than the recommended levels. Similar findings were also reported by Sarupriya and Mathew (1988), Sarojini and Vijayalakshmi (1989), Llamas *et al.*, (1996) and Ahmed *et al.*, (1997).

With respect to nutrient intake, except calcium, thiamine and vitamin C, the intake of all other nutrients was found to be lower than the RDA in adolescent boys. Even though the intake of fruits was nil in the diet the vitamin C content was found to be very high, may be due to the high intake of roots and tubers i.e., tapioca, which contain considerably higher amounts of vitamin C. Although the intake of vitamin C was found to be very high, it may not be fully available to the body, because the loss of vitamin C in cooking is very high. Sood and Bhat (1974) also opined that there is considerable loss of vitamin C during cooking due to leaching and oxidation of ascorbic acid. In the case of adolescent girls energy, thiamine and niacin intake was found to be higher than the RDA. In 2/3rd and full

RDA groups, calcium, iron and retinol intake was also found to be higher than the RDA. The intake of all other nutrients was lower than the RDA. Nagi *et al.* (1994) reported inadequate intake of energy iron, calcium, vitamin A and ascorbic acid among adolescents. Kocchar *et al.*, (1995) reported deficiency of energy, protein and iron and higher amounts of calcium and thiamin in the diet of adolescents. In this study, the vitamin and mineral intake were found to be higher in 2/3rd and full RDA groups than the control group.

5.4.3 Clinical examination

Clinical manifestations are important indices of nutritional deficiencies, clinical examination of adolescents revealed that adolescents in all the three groups manifested one or other variable signs of deficiency diseases before and after the study. McCoy and Kenny (1984) reported that adolescents is a critical period in the development of deficiency diseases. In the present study anaemia and dental caries were more prevalent among adolescents in all the three groups before study. After the supplementation the number of adolescents with dental caries increased and number of adolescents with anaemia showed reduction in all the three groups. High incidence of dental caries was reported from Kerala by Pant and Solanki (1989) and Paul (1993). The other diseases prevalent among adolescents included bilots spot, phrynoderma, mottled enamel and koilonychia.

5.4.4 Haematological indices

Haematological indices like haemaglobin level, RBC count and packed cell volume were analysed before and after the supplementation study.

The results revealed that haemotological indices showed increments in all the three groups. On analysing the data, it can be seen that the highest increment was in full RDA group than the other two groups after the supplementation study. Statistical analysis of the data revealed that the increments in mean haemoglobin and packed cell volume in all the three groups after the study was significant. In the case of RBC count the increase in the mean value was non significant in

control group of adolescent boys. In 2/3rd and full RDA groups the increments after the study was significant.

The haematological indices of adolescents before and after the study were compared with normal values. The results revealed that none of the adolescents had normal haemoglobin values before and after the supplementation study showing prevalence of anaemia. The mean haemoglobin levels of adolescents ranged between 8-12 g/dl. The percentage of adolescents with haemoglobin level ranging between 8-10 g/dl showed decline and 10-12 g/dl showed increment in all the three groups after the supplementation study.

The RBC count and packed cell volume of adolescents in all the three groups were below the normal values before the supplementation study. After the supplementation study 2.5 per cent, 2.5 per cent and 5 per cent of the adolescents in the control 2/3rd RDA and full RDA group respectively had normal values with respect to RBC and PCV.

Analysis of variance was done to compare the mean haematological values of three groups indicated that in adolescent boys significant difference was observed among the three groups with regard to the three haematological indices. In the case of girls, with regard to haemoglobin levels, significant difference was observed between control and 2/3rd RDA group and 2/3rd and full RDA group. The difference existed between control and full RDA group was not significant. In the case of RBC count significant difference was observed between control and full RDA group. The difference existed between the control and 2/3rd RDA group and 2/3rd RDA and full RDA group was not significant. In girls the PCV showed significant difference between all the three groups after the supplementation study.

Nutritional anaemia has been defined as a condition in which the haemoglobin content of blood is lower than the normal as a result of one or more essential nutrients (WHO, 1979). Agarwal (1991) had reported that nutritional anaemia is characterised by inadequate erythropoeisis and reduced haemoglobin concentration which is due to inadequate supply of nutrients like iron, folic acid and vitamin B12.

In the present study, although adolescents in all the three groups showed increments in haemoglobin levels, they could not attain normal values after the supplementation study and remained anaemic. NIN (1995) reported that iron deficiency anaemia may occur due to poor absorption caused by dietary inhibitors like phytates oxalates and tannins. Interplay of these inhibitors and level of enhancers like ascorbic acid determined the availability of iron from the diets. Greenwood (1979) stated that iron deficiency anaemia is undoubtedly one of the most serious public health problem related to nutrition during adolescence. Raman *et al.* (1985), Kapoor and Aneja (1992), Paul (1993), Nagi *et al.* (1995), Ranani (1995), Chaturvedi *et al.* (1996) and Johndhale *et al.* (1999) reported prevalence of anaemia among adolescent.

Devadas and Saroja (1979) conducted a study on the availability of iron and β carotene from amaranth among children and indicated that amaranth species are excellent source of iron and β carotene and could help to alleviate iron and vitamin A deficiencies. The supplementation trial conducted by them showed increase in haematological indices. This was in agreement with the findings of this study in which the highest increment in haematological values was reported in the experimental group supplemented with full RDA and higher in 2/3rd RDA compared to control group.

5.5 Effect of feeding amaranth on the functional performance of adolescents

Functional performance of adolescents were measured using Harvard step test.

The results showed increments in the mean scores in all the three groups after the study period. The highest increment in mean scores was observed among the adolescents of full RDA group and higher increase in 2/3rd RDA group compared to control group. Statistical analysis of the data revealed that the

increment in mean scores after the study period was significant in all the three groups.

The distribution of adolescents into different physical conditions based on the mean scores obtained in the functional performance test revealed that none of the adolescents had excellent and good physical condition before and after the supplementation study. A decrease in the percentage of adolescent with poor physical condition was observed in all the three groups after the study period. Percentage of adolescents with low average physical condition showed increment in $2/3^{rd}$ and full RDA group after the supplementation study. The percentage of adolescents with high average physical condition showed increment in all the three groups with highest increase in full RDA group. Analysis of variance was done to compare the means and indicated significant difference was existed among the three groups after the supplementation study.

Vijayalakshmi and Selvasundari (1983) had stated that iron deficiency anaemia affects the physical work capacity by reducing the availability of oxygen to the tissues, which inturn affects cardiac output. Nelson *et al.* (1994) assessed the relation between iron deficiency anaemia and physical performance in adolescent girls and found that physical work performance is compromised even at mild levels of anaemia.

In the present study, adolescents were anaemic before supplementation. Haematological indices of adolescents showed increment after supplementing amaranth in the diet, but they were not completely rid of the anaemic condition. Similarly the mean score of functional performance test showed lower values before supplementation. After the study, increase in mean scores was observed with increase in haematological indices. So the findings of Nelson *et al.* (1994) is in agreement with the findings of this study.

The results revealed that the nutritional status of adolescents showed improvement after 6 month supplementation of amaranth in the diet. Although

none of the adolescents could achieve the normal nutritional status, they showed improvement in nutritional status after the supplementation study with greater improvement in full RDA and 2/3rd RDA compared to control group. The results of the study is in agreement with the findings of Devadas and Saroja (1979) who reported amaranth as an effective supplement in improving iron status in children. The results of the study showed improvement in anthropometric measurements, haematological indices, functional performance and clinical manifestations of adolescents after the supplementation study. In general it can be concluded that amaranth supplementation has got a positive influence on the health and nutritional status of adolescents.

SUMMARY

SUMMARY

The present study entitled 'Effect of amaranth on the health and nutritional profile of adolescents' was conducted among 120 adolescents between 13 to 15 years of age. The samples were selected from juvenile home and orphanage in Trichur district on the basis of occurrence of anaemia and divided into three groups, control 2/3rd RDA and full RDA, consisting 40 adolescents in each group.

The study was carried out to throw light on the food consumption pattern of the inmates of the institutions, acceptability of amaranth recipes, nutrient composition of fresh amaranth and selected recipes and health and nutritional status of adolescents before and after the supplementary feeding trial using amaranth.

Food consumption pattern of the inmates of the institutions indicated that all the inmates were non vegetarians and rice formed their staple food. The daily used food items by institution I included cereals, pulses, roots and tubers, other vegetables, milk, fats and oils, sugar and spices and institution II used cereals, other vegetables, milk, fats and oils, sugar and spices daily. Both institutions maintained records of their income and expenditure in written form on a daily basis.

Advanced meal planning was popular in both the institutions. Boiling was the most common method adopted for cooking by both the institutions.

The acceptability study of amaranth recipes were carried out using score card. The important characters like appearance, flavour, colour, texture and taste were evaluated by a panel of judges. In the acceptability study cheera minced meat thoran obtained the highest score (18.51) and cheera pittu scored the lowest (10.17) out of a maximum score of 25. The ten recipes selected for feeding trial were

cheera chappathi (17.40), cheera curry (18.39), cheera vada (17.99), cheera cutlet (17.76), cheera dhal maseel (18.12), cheera minced meat thoran (18.51), cheera green gram thoran (17.82), cheera thoran (18.49), cheera egg thoran (18.17) and cheera pachadi (18.46).

The fresh amaranth and ten amaranth recipes were analysed for the protein, starch, soluble carbohydrate crude fibre, calcium, iron, β carotene and vitamin C contents. The protein content of fresh amaranth was 3.34 per cent and it ranged between 1.81 per cent and 8.34 per cent in amaranth recipes. The starch and soluble carbohydrate content of fresh amaranth was 0.20 per cent and 1.68 per cent respectively and in amaranth recipes, ranged between 0.31 per cent to 33.23 per cent and 1.04 per cent to 12.70 per cent respectively. The crude fibre content of fresh amaranth was 1.72 per cent and in recipes, ranged between 0.78 to 2.91 per cent. Calcium and iron content of fresh amaranth was 197.30 and 20.52 mg $100g^{-1}$ and in recipes, ranged between 152.98 to 252.98 mg $100g^{-1}$ and 21.29 to 13.99 mg $100g^{-1}$ respectively. The ß carotene content of fresh amaranth was 14064 µg $100g^{-1}$ and in recipes, ranged from 5205 µg $100g^{-1}$ to 10280 µg $100g^{-1}$. The vitamin C content of fresh amaranth was 136.55 mg $100g^{-1}$ and in recipes, ranged between 53.79 to 75.85 mg $100g^{-1}$.

The mean food intake of adolescents in comparison with recommended allowances suggested by ICMR (1989) showed that intake of cereals, milk and milk products fats and oils sugar and jaggery were lower than the RDA. Green leafy vegetables was not included in the diet of control group. Intake of roots and tubers was found to be higher in boys and lower in girls compared to RDA. Intake of pulses and other vegetables was higher than the RDA. Fruits and fleshy foods were not included in the diet of boys but found to be lower than the RDA in girls.

The mean intake of different nutrients in comparison with RDA (ICMR, 1990) revealed that except for calcium in $2/3^{rd}$ and full RDA groups as well as thiamine and vitamin C in all the three groups, the intake of all other nutrients were

found to be lower than the RDA among adolescent boys. In adolescent girls energy, thiamine and niacin intake in the control group and calcium iron and retinol intake in 2/3rd and full RDA groups were found to be higher than the RDA.

The anthropometric measurements like height and weight showed increments in all the three groups after the study with greater increment in 2/3rd and full RDA group compared to control group. The increments in height and weight after the supplementation study were found to be statistically significant. The distribution of adolescents based on weight for height and body mass index (BMI) revealed beneficial changes in the nutritional status of adolescents in all the three groups after the study period.

The most common deficiency disease observed among adolescents was anaemia, and a reduction in the number of anaemic adolescents was noticed in all the three groups after the study period. Dental caries was also observed among adolescents irrespective of the groups and it even increased after the study period. This is mainly due to poor oral hygiene of the adolescents.

Haematological indices, viz., haemoglobin level, RBC count and packed cell volume showed increase in mean values after the study. The increments in haemoglobin values and packed cell volume were found to be statistically significant in all the three groups. The increments in RBC count except in adolescent boys of the control group, in all other group it was found to be statistically significant.

The mean scores of the functional performance test also showed increase in all the three groups after the study period and this increments were found to be statistically significant. The increase in the mean scores among adolescents of 2/3rd and full RDA group were found to be greater than the control group.

The nutritional status of adolescents showed improvements after the six months supplementation study. Although, none of the adolescents could achieve normal nutritional status, they showed improvement in nutritional status after the study with greater improvement in full RDA and 2/3rd RDA groups compared to control group. In general it can be concluded that amaranth supplementation has got a positive effect on the nutritional status of adolescent.

REFERENCES

REFERENCES

Abraham, S. 1997. *Nutrition in Everyday Life*. Keerthi Publishing House Pvt. Ltd. p.47-57

Aebi, H.E. 1983. Biochemical parameters as indicators for the nutritional status. *Fourth Asian Congress of Nutrition Programme and Abstracts*, p.70

Agarwal, K.N. 1991. Functional consequences of nutritional anaemia. *Proc. Nutr. Soc. India*. National Institute of Nutrition, Hyderabad. **37**:127

Ahmed, F., Hasan, N. and Kabir, Y. 1997. Vitamin deficiency among adolescent female garment factory workers in Bangladesh. *European J. Clin. Nutr.* **51**(10):698-702

Akkamahadevi, K.H., Kasturiba, B. and Katarki, P.A. 1998. Energy and blood forming nutrients in the diets of rural and urban adolescent girl. *Indian J. Nutr. Dietet.* **33**(4):95

Akpanyung, E.O., Udoh, A.P. and Akpan, E.J. 1995. Chemical composition of edible leaves of *Pterocarpus mildbraedii*. *Pl. Fds hum. Nutr.* **48**(3):209-215

Alleman, J., Heever, E.V.D. and Viljoen, J. 1996. Evaluation of *Amaranthus* as a possible vegetable crop. *Appl. Pl. Sci.* **10**(1):1-4

Aman. 1969. *Medicinal Secrets of Your Food.* Indo American Hospital Trust, Bangalore. p.307-390

Andersen; L.F., Nes, M., Lillegaard, I.T., Sandstad, B., Bjorneboe, G.E. and Drevon, C.A. 1995. Dietary intake among Norwegian adolescents. *European J. Clin. Nutr.* **49**(8):555-564

A.O.A.C. 1955. *Official and Tentative Methods of Analysis*. 8th ed. Association of Official Analytical Chemists, Washington, DC

A.O.A.C. 1970. *Official and Tentative Methods of Analysis*. 11th ed. Association of Official Analytical Chemists, Washington DC

Bali, P. 1990. Indian adolescent and their health and reproductive health. Proc. of the Workshop on towards the preparation of Adolescent girls for Safe Motherhood Through the ICDS Programme. National Institute of Public Co-operation and Child Development, Delhi, p.83

Banik, D.N.D. 1979. Psycho-social behavioural problems of children during adolescence. *Indian J. Pediatrics*. **46**:121

Bass, M.A., Wakefield, L. and Kolara, 1979. *Community Nutrition and Individual Food Behaviour. Burgers Publishing Company, Minnesota.p.78-82*

Bhatia, D. 1987. Relation between anaemia and work capacity. *Indian Pediatrics.* **24**:133

Bindu, B., Bandyopathy and Chattopadhyaya, H. 1979. Dietary studies on urban and rural male college students. *Indian J. Nutr. Dietet.* **17**(5):183

Bodyfelt, F.W., Tobias, J. and Trout, G.M. 1988. The *Sensory Evaluation of Dairy Products.* AVI Publishing Co., New York

Bozz, A., Nassanato, P., Geeco, A.M. and Ganbardella, S. 1980. qualitative study of the nutritional habits of two population of compulsory intermediate school in Nepal. *Nutr. Abs. and Reviews* **52**:6

Bressani, R., Elias, L.G. and Bosque, C. 1988. The supplementary value of amaranth leaves to cereal grain based diets. *Amaranth News L.* **1**:1

Brouha, L. 1943. The step test: A simple method of measuring physical fitness for Muscular work in Young Men. *Res. Quarterly* **14**(1):31

Bull, N.L. 1992. Dietary habits, food consumption and nutrient intake during adolescence. *J. Adol. Health.* **13**(5):384-388

Bundy, K.T., Morgan, K.J. and Zakik, M. 1982. Nutritional adequacy of snacks and sources of total sugar intake among U.S. adolescents. *J. Canadian Dietet. Assoc.* **43**(4):358-365

Carlisle, J.C., Bass, M.A. and Onestry, D.W. 1980. Food preference and cannotative meaning of foods of Alabanna teenagers. *School Fd Serv. Res. Rev.* **4**(1):19

Castanedac, L., Surnez, G.R. and Valadezi, A. 1986. Evaluation of amaranth (*a. hypochondriacus*) as vegetable, in comparison with spinach (*spinacia oleracea* L.). *Amaranth News L.* **3**:3

Chaturvedi, S., Kapil, U., Gnanasekaran, N., Sachdev, H.P.S., Pandey, R.M. and Bhanli, T. 1996. Nutrient intake amongst adolescent girls belonging to poor socio-economic group of rural area of Rajasthan. *Indian Pediatrics* **33**(3):197-201

Chavance, M. and Dumar, M.A. 1982. Beverage intake by children and adolescents - variation factor. *World Rev. Nutr. Dietet.* **40**:82

Chopdar and Mishra, P.K. 1981. Health status of rural school children in Western Orissa. *Indian J. Pediatrics* **47**(3):386

Chopra, S.L. and Kanwar, J.S. 1978. Analytical Agricultural Chemistry. Kalyani Publishers, Ludhiana

Dacie, J.V. and Lewis, S.M. 1975. *Practical Haematology*. Churchhil Livingtone Pub. London, p.31-94

Daphna, W.N. 1979. Biochemical appraisal of vitamin nutritional status in man. *JAMA*. **18**:49

Davidson, S., Passmore, R. and Brook, J.F. 1980. *Human Nutrition and Dietetics*. The English Language Book Society, Livingstone, p.178

DeMaeyer, E. 1989. The Prevalence of Anaemia in the world. *World Health Statistics Quarterly*. **38**:302-316

Desai, I.P. 1996. Dietary pattern and nutritional profile of children. *J. ICCW* **3**(2):28-36

Devadas, R.P. and Chandrasekhar, U. and Kumari, K.S. 1973. Availability of iron from *Amaranthus* cooked in two different utensils. *Indian J. Nutr. Dietet.* **10**:223

Devadas, R.P. and Easwaran, P.P. 1991. Food supplements and logistics of food supply. *Indian J. Nutr. Dietet.* **28**(7):181-187

Devadas, R.P., Kamalanathan, G. and Vijayalakshmi, P. 1981. Leaf protein feeding trial with children at Coimbatore: Evaluation of the leaf protein feeding programme. *Indian J. Nutr. Dietet.* **18**:427-434

Devadas, R.P. and Kulandaivel, K. 1975. *Handbook of Methodology of Research*. Sri Ramakrishna Mission Vidhyalaya Press, Coimbatore, p.5-54

Devadas, R.P. and Saroja, S. 1979. Availability of iron and ß carotene from amaranth to children. *Proc. Second Amaranth Conf.* Rodak Press Inc. 33. East Minor Street, Emmaus, p.15-21

Devadas, R.P. and Saroja, S. 1987. Dietary supplementation and vitamin A nutrition of rural children. *Indian J. Nutr. Dietet.* **24**:2-8

*Hamdaoui, M., Hedhill, A., Tritar, B. and Dogri, T. 1991. Study of iron status in an adolescent population including both sexes in the region of Tunis. *Medicine Nutr.* **27**(4):209-214

Haugen, D.L. 1981. The relationship of family meals to food habits and attitudes of youth in Minnesota. University of Minnesota.

Howson, C.P., Kennedy, E.T. and Horwiz, A. 1998. Prevention of micronutrient deficiencies - tools for policy makers and public health workers. National Academy Press, Washington. p.92-98

ICMR. 1984. *Recommended Dietary Intake for Indians*. ICMR, New Delhi

ICMR. 1990. Nutrient requirements and recommended dietary allowances for Indians. ICMR, New Delhi

Islam, M.N., Genuario, R.R. and Pappas, M. 1987. Nutritional and sensory evaluation of *Atriplex triangularis* leaves. *Fd Chem.* **25**(4):279-284

James, W.P.T., Luizzi, F. and Waterlow, J.C. 1988. Definition of chronic energy deficiency in adults – Report of working party of the intervention dietary energy consultation group. *Am. J. Clin. Nutr.* **42**:969-981

Jelliffe, D.B. 1966. The assessment of the nutritional status of the community. *WHO Monograph Series*, 33. W.H.O., Geneva

Jellinek, G. 1985. Sensory evaluation of food – Theory and Practices. Ellis Horwood Ltd., Chichesta England and VCH Verlagsgerellschaft mbH weinhein, Federal Republic of Germany. P.284

Jijiamma, N.C. 1989. Nutritional profile of amaranthus as influenced by post harvest handling. M.Sc(Homescience) thesis, Kerala Agricultural University, Trichur

John, K.C., Gourley, L. and Lee, A.P. 1987. Dietary fibre and starch contents of some South East Asian vegetables. *J. agric. Fd. Chem.* **35**(2):319-321

Johndhale, J.P., Reddy, N.S. and Nalwade, V.M. 1999. Prevalence of anaemia among school going adolescent girls of Parbhani. *Indian J. Nutr. Dietet.* **36**:268-274

Kala, A., Narasimhan, S. and Prakash, J. 1998. Nutrient contents and sensory attributes of microwave versus conventionally cooked greens. IFCON '98. 4th International Food Convention, Mysore, November 23-27. *Abstracts of Poster Paper*. p.119

Kamath, S. 1986. *Nutritional assessment in health assessment* (3rd ed.). The c.V.Mosby Company, St. Louis, Toronto, Princeton. P.132

Kanani, S. 1995. Strategies for combating anaemia in adolescent girls. *Indian J. Pediatrics* **62**(3):375-377

Kapoor, G. and Aneja, S. 1992. Nutrition disorders in adolescent girls. *Indian Pediatrics* **29**(8):969-973

Kaur, B. and Manjrekar, S.P. 1975. A study on the chemical composition of green leafy vegetables available in Northern India. *Indian Fd Packer.* **29**(3):71-72

Khan, M.A. and Lipke, L.K. 1982. Snacking and its contribution to food and nutrient intake of college students. *J. Am. Dietet. Assoc.* **8**(5):583-587

Khangaonkar, M.B., Ramakrishnan, S., Ghutrani, K.K., Murthi, G.V.S., Nayar, S. and Vidwani, P. 1990. Vitamin A intake and vitamin A deficiency in rural children. *Indian Pediatrics* **27**(5):443-446

Kochhar, A., Hira, C.K., Sadana, B., Grover, K. and Mann, S.K. 1995. Nutrient adequacy of rural adolescent boys in Ludhiana District of Punjab. *J. Res. Punjab Agric. University.* **32**(1):98-106

Kohli, S. 1988. A study on food habits calorie intake physique and stress pattern of adolescent college girls of the Twin cities. M.Sc. thesis submitted to A.P. Agricultural University, Andhra Pradesh.p.35

*Korede, O. and Ajayi, O.A. 1991. Plasma vitamin B6 concentration in Nigeria adolescents. *European J. Clinc. Nutr.* **45**(2):111-115

Kowsalya, S. and Mohandas, S. 1999. Acceptability of nutrient profile of cauliflower leaves. *Indian J. Nutr. Dietet.* **36**:322-324

Krishnakumari, M. and Rao, P. 1983. A. Survey of college hostels in Twin cities. *Indian J. Nutr. Dietet.* **20**:95

Kushwaha, A., Shukla, P. and Raghuvanshi, R.S. 1998. Development of iron and ß carotene rich snacks for young children IFCON '98, 4th International Food Convention, Mysore, November 23-27. *Abstracts of Poster Papers.* p.214

Lakshmi, B. and Vimala, V. 1998. Development of nutritions dehydrated green leafy vegetable powder blends. IFCON '98. 4th International Food Convention, Mysore, November 23-27. *Abstracts of Poster Papers.* p.124

Lindzey, J. 1954. *Handbook of Social Psychology* (Vol.I). Anderson and Westey Publication, London. p.449

Llamas, F.P., Gasaulet, M., Nieto, M., Baraza, J.C. and Zamora, S. 1996. Estimates of food intake and dietary habits in a random sample of adolescents in South East Spain. *J. Human Nutr. Dietet.* 9(6):463-471

Lopez, R., Schwartz, J.V. and Cooperman, J.M. 1980. Riboflavin deficiency in an adolescent population in New York city. *Am. J. Clinc. Nutr.* **33**(6):1283-1286

Lorenz, K. and Hwang, Y.S. 1985. Lipids in amaranthus. *Nutr. Rep. Int.* **31**(1):83-89

Lucas, E.O. 1988. The potential of leaf vegetables in Nigeria. *Outlook Agric.* **17**(4):163-168

Mahan, K. and Ress, J.M. 1984. *Nutrition in Adolescence*. Times Mirror/Mosky College Publishing, U.S.A. p.72-75

Manocha, S., Gupta, M.C. and Gandhi, B.M. 1988. Difference in dietary intake of obese females belonging to different income groups. *Indian J. Nutr. Dietet.* **22**:52

Marin, M.V.G., Casello, L.D., Alvise, S. 1988. Dietary habits of students of physical education. *Nutr. Abs. Rev. Series* **60**:7

Marshall, W.A. and Tanner, J.M. 1986. *Human Growth*. A comprehensive Treatise 2nd edition. p.171-209

Mathur, B., Joshi, R.N. and Ray, W.J. 1989. Impact of supplementing leaf protein concentrate on haemoglobin levels of children. *Indian J. Nutr. Dietet.* **26**:267-271

McCoy, J.H. and Kenny, M.A. 1984. Adolescent girls consumption of energy, energy supplying nutrients cholesterol and sodium. *Nutr. Rep. International* **30**(6):1343

McDemott, I.J. 1992. The importance of sensory analysis for evaluation of quality. *Fd. Tech. Abstracts* **27**(5):167

*Mei-Qin, C. and Wen-Yu, Y. 1990. Study on iron nutritional status in adolescence. *Biomedical and Environmental Sciences* 3(1):113-119

Menon, K. 1980. What is great about greens? *Nutr.* **14**(1):20

Miric, J. and Parezanovic, J. 1979. Dietary habits of students. *Nutr. Abs. Rev. Series* **52**(3):143-150

Mohideen, M.K., Rangaswami, P., Metha, V.A., Shunmughavelu, K.G. and Muthukrishnan, C.R. 1985. A note on CO-3 Amaranthus. *S. Indian Hort.* **33**(2):127-128

Mosha, T.C., Pace, R.D., Adeyeye, S., Mtebe, K. and Laswai, H. 1995. Proximate composition and mineral content of selected Tanzanian vegetables and the effect of traditional processing on the retention of ascorbic acid, riboflavin and thiamine. *Pl. Fds Hum. Nutr.* **48**(3):235-245

Moynihan, P.J., Anderson, C., Adamson, A.J., Rugg-Gunn, A.J., Appleton, D.R. and Butler, T.J. 1994. Dietary sources of iron in English adolescents. *J. Human Nutr. Dietet.* 7(3):225-230

*Mugerwa, J.S. and Bwabye, R. 1974. Yield composition and *in vitro* digestability of *Amaranthus hybridus* sub sp. *incurvatus*. *Trop. Grasslands.* **8**(1):49-43

Musgrave, K.O., Achterber, C.L. and Thorukury, M. 1981. Strategies for measuring adolescent snacking pattern. *Nutr. Rep. Int.* **24**(3):557-573

Nagi, M.K., Chawla, S. and Sharma, S. 1994. Nutritional profile of adolescent girls in Ludhiana city. *J. Res. Punjab Agric. University* **31**(3):353-358

Nagi, M.K., Chawla, S. and Sharma, S. 1995. A study on the nutritional status of adolescent girls. *Pl. Fds. Hum. Nutr.* **47**(3):201-209

Neeliyara, A.M. 1998. Nutritive value and acceptability of winged bean genotypes (*Psophocarpus tetragonolobus* L.). M.Sc(HomeScience) thesis, Kerala Agricultural University, Thrissur

Nelson, M., Bakaliou, F. and Trivedi, A. 1994. Iron deficiency anaemia and physical performance in adolescent girls from different ethnic backgrounds. *British J. Nutr.* **72**(3):427-33

Nelson, M., White, J. and Rhodes, S. 1993. Haemoglobin, Ferritin and iron intakes in British children aged 12-14 years: a preliminary investigation. *British J. Nutr.* **70**(1):147-155

NIN. 1990a. Body mass index. *Nutr. News.* National Institute of Nutrition, Hyderabad. **12**:4

NIN. 1990b. Growth of Indian boys and girls during adolescence. Annual report 1989-90. National Institute of Nutrition, Hyderabad. **12**:2

NIN. 1991a. *Nutritive value of Indian foods*. National Institute of Nutrition, Hyderabad. p.48

NIN. 1991b. Carotene content of foods. Annual Report 1991-92. National Institute of Nutrition, Hyderabad. p.56-7

NIN. 1994. Carotene content of foods. Annual Report 1994-95. National Institute of Nutrition, Hyderabad. p.135-136

NIN. 1995. Food Composition and Nutrient availability. Annual Report 1995-96. National Institute of Nutrition, Hyderbad. p.65

NNMB. 1996. National Nutrition Monitoring Bureau. Report of repeat survey. National Institute of Nutrition, Hyderabad

Ninsing, S. and Shaw, N.S. 1996. Iron deficiency and anaemia in school children and adolescents. *J. Forsman Med. Assoc.* **95**(9):692-698

*Norderide, M.b., Hatloy, A., Folling, M., Lied, E. and Oshang, A. 1996. Nutrient composition and nutritional importance of green leaves and wild food resources in an agricultural district, Koutiala in Southern Mali. *Int. J. Fd Sci. Nutr.* **47**(6):455-468

Olatunbosun, D.A., Adadevoh, B.K. and Oke, O.L. 1972. Leaf protein: a new protein source for the management of protein calorie malnutrition in Nigeria. *Nigerian med. J.* **2**:195-199

Padmavathi, P. and Rao, M.P. 1990. Nutritive value of *Sauropus androgynus* leaves. *Pl. Fds. Hum. Nutr.* **40**(2):107-113

Pal, D., Sachdeva, S. and Singh, S. 1995. Methods for determination of sensory quality of foods. A critical appraisal. *J. Fd Sci. Technol* **32**:27-30

Pandey, D. 1995. Dietary pattern among early adolescent orphans. *Am. J. Clin. Nutr.* **60**(2):472-479

Pant, I. and Solanki, P.K. 1989. Assessment of health and nutritional status of under privileged school aged boys with special emphasis on vitamin A deficiency. *Proc. Nutr. Soc. India.* National Institute of Nutrition, Hyderabad.

Patki, P.E., Pandit, S.S. and Arya, S.S. 1998. Development and storage stability of instant vegetable-dhal curry mixes. IFCON '98. 4th International Food Convention, Mysore, November 23-27. *Abstracts of Poster Papers*. p.19

Paul, M.E. 1993. Food preference and dietary habits of adolescents among agricultural labourers. M.Sc. (HomeScience) thesis, Kerala Agricultural University. p.120

Pearce, J.H., Ahos, R.J. and Terry, R.D. 1987. Attitudes towards eating and reported dieting practices of adolescent girls in relation to body image. *J. Newzealand Dietet Assoc.* **4**:41

Perkin-Elmer. 1982. Analytical Methods for Atomic Absorption Spectrophotometry.

Perron, M. and Endres, J. 1985. Knowledge, attitudes and dietary practices of female athelets. *J. Am. Dietet. Assoc.* **85**(5):573-576

Philip, J., Peter, K.V. and Gopalakrishnan, P.K. 1981. Curry leaf - a mineral packed leafy vegetable. *Indian Hort.* **25**(4):2-3

Phillippe, I., Bondies, F., Mazlin, A., Bourderon, D. and Pinochet, C. 1988. Study of dietary habits of adolescent girls 12-18 year old. *British J. Nutr.* **85**(4):573-576

Place, J.L. 1980. *Nutrition in Adolescence*. Times Mirror/Mosky College Publishing, USA. p.100

Port, B., Han, C.G., Keimpa and Storm, L. 1987. Energy intake of adolescents - A comparison. *British J. Nutr.* **57**(16):176

Prakash, D., Nath, P. and Pal, M. 1993. Analysis of nutritional contents in Amaranthus, Chenopodium and Celosia leaves. Golden Jubilee Symposium Horticultural Society of India, Bangalore, May 24-28. *Abastracts of papers*. p.375

Prattala, R. 1988. socio-demographic differences in fat and sugar consumption patterns among adolescents. *Ecology Fd. Nut.* **22**(1):53-64

Premavalli, K.S., Madhura, C.V. and Arya, S.S. 1998. Minor nutrient quality of dehydrated green leafy vegetables IFCON '98. 4th International Food Convention, Mysore, November 23-27. *Abstracts of Poster Papers*. p.118

Pushpamma, P., Geervani, P. and Devi, N.L. 1982. Food intake, nutrient adequacy and anthropometry of adolescnts in Andra Pradesh. *Indian J. Med. Res.* **75**:61-67

Raja, T.K., Othman, O.C. and Bahemukha, T.E. 1997. Levels of crude proteins and some inorganic elements in selected green vegetables of Dares Salaam. *J. Fd Sci. Technol.* **34**(5):419-422

Rajagopal, A., Muthukrishnan, C.R., Mohideen, M.K. and Syed, S. 1977. CO-2 Amaranthus - An early vigorous variety. *S. Indian Hort.* **25**(3):102

Rajesh, J. 1991. Implications of changing food habits. *J. Nutr. Education* **12**(1):211

Raman, L., Rau, P. and Rao, U. 1985. Nutritional status and age at menarche. *Proc. Nutr. Soc. India*. National Institute of Nutrition, Hyderabad. p.31-83

Ranganna, S. 1977. *Mannual of Analysis of Fruit and Vegetable Products.* Tata McGraw-Hill Publishing Company Limited, New Delhi

Rao, C.N. 1983. A survey of the diets in residential hostels in India. *Indian J. Med. Res.* **54**:475-479

Rao, K.V. 1975. Diet survey by weighment method - A comparison of reference periods. *Indian J. Nutr. Dietet.* **12**:9-10

Rao, N. 1985. Nutrient requirements of adolescents. *Proc. Nutr. Soc. India*. p.110-112

Rao, S. 1990. Variations in Anthropometry and Dietary intake among adolescent girls in a follow-up study. Proc. of the Workshop on towards Preparation of adolescent Girls for Safe Motherhood through the ICDS programme. National Institute of Public Co-operation and child Development. p.196

Rao, D.H. and Vijayaraghavan, K. 1996. Anthropometric assessment of nutritional status - *Textbook of Human Nutrition.* (eds. Bamji, M.S., Rao, N.P. and Reddy, V.). Oxford and IBH Publishing Co. Pvt. Ltd. p.148-162

Rau, A.G., Bolakil, L.D. and Puttaraj, S. 1998. Development of food products incorporated with green leafy vegetables and their acceptability IFCON '98. 4th International Food Convention, Mysore, November 23-27. *Abstracts of Poster Papers.* p.9

Reddy, C.V.K. 1999. Greens for good health. *Nutr.* **33**(3):3-8

Reddy, V., Rao, N.P., Sastry, J.G. and Kashinath, K. 1993. *Nutrition Trends in India*. National Institute of Nutrition, Hyderabad, India. p.36-37

Sadasivan, S. and Manikam, A. 1992. *Biochemical Methods for Agricultural Sciences*. Wiley Eastern Ltd., New Delhi & Tamil Nadu Agricultural University, Coimbatore

Saini, M. and Verma, S. 1989. Assessment of nutritional status of school girls. *Scientific prog. Abs*. Nutrition Society of India.p.59

Salar, J., Galan, P., Arija, U., Henneburg, C.m. and Horckerg, S. 1990. Iron status and food intake in a representative sample of children and adolescents. *Nutr. Res*. **10**(4):379-390

*Samuelson, G., Boratteby, L.E., Berggren, K., Elverby, J.E. and Kempe, B. 1996. Dietary iron intake and iron status in adolescents. *Acta Pediatrica* **85**(9):1033-1038

Sarojini, K.S. and Vijayalaskhmi, P. 1989. Adequacy of recommended dietary allowances of ICMR for adolescent girls. *Indian J. Nutr. Dietet.* **26**(6):150

Sarupriya, S. and Mathew, S. 1988. Nutritional status of tribal adolescents of village Gogunda, Rajastan. *Indian J. Nutr. Dietet.* **25**(9):281-287

Sathyanarayana, K. 1988. Growth and Development and physical performance of man in under nutrition - Social Dimension. *Proc. Nutr. Soc. India*. National Institute of Nutrition, Hyderabad. **34**:23-34

*Sato, F., Milwa, S., Murayama, A. and Fujitoc, N. 1984. Breakfast and supper taken by Junior College students as reflected in combinations of group of dishes. *Japanese J. Nutr.* **42**(2):91-97

Sausberlich, H.E., Dowdy, R.P. and Skala, J.H. 1977. *Laboratory Tests for the Assessment of Nutritional status*. CRC Press, Inc., Cleveland, Ohio

Shah, f.H., Sheikh, S.A., Faorhkh, N. and Rasool, A. 1981. A comparison of leaf protein concentrate fortified dishes and milk as supplements for children with nutritionally inadequate diets. *Indian Pediatrics* **28**:234-238

Sharma, S.D. and Kalia, M. 1990. Anthropometric measurements of preschool children in Ghumanum block of Himachal Pradesh. *Indian J. Nutr. Dietet.* **27**(2):47-52

Shingade, M.Y. and Chawan, K.N. 1996. Unconventional leafy vegetables as a source of minerals. *Van Vigyan.* **34**:1-6

Shingade, M.Y., Chawan, K.N. and Gupta, D.N. 1995. Proximate composition of unconventional leafy vegetables from the Konkan region of Maharashtra. *J. Fd. Sci. Technol.* **32**(5):429-431

Shivpuri, B. 1990. Health and Nutritional Problems of adolescent girls. Proc. of the Workshop on Towards the Preparation of Adolescent Girls for safe Motherhood through the ICDS Programme. National Institute of Public Co-operation and Child Development, Delhi. p.74

Smith, I.F. 1982. Leafy vegetables as sources of minerals in southern Nigerian diets. *Nutr. Rep. Int.* **26**(4):679-688

*Someya, R., Negishi, Y., Mizunto, K. and Muto, S. 1989. Snacking habits in adolescents. *Japanese J. Nutr.* **47**(6):283-291

Sood, R. and Bhat, C.M. 1974. Changes in ascorbic acid and carotene content of green leafy vegetables on cooking. *Pl. Fd. Human. Nutr.* **37**(1):291

Soof, G.S. 1967. Iron deficiency infections and immune function. A reassessment. *Am. J. Clin. Nutr.* **31**:660-666

Sreeramulu, N., Ndossi, G.D. and Mtotomwema, K. 1983. Effect of cooking on the nutritive value of common food plants of Tanzania. 1. Vitamin C in some of the wild green leafy vegetables. *Fd Chem.* **10**:205-210

Story, M. and Alton, I. 1996. Adolescent nutrition - current trends and critical issues. *Topics Clinc. Nutr.* **11**(3):56-69

Swaminathan, M.C. Taskar, A.C. and Madhavan, S. 1967. Diet surveys by weightment method. A comparison of random day, 3 day and 7 days period. *Indian J. Med. Res.* **55**:90-95

Swaminathan, M.C. 1987. Non-invasive parameters for field monitoring and evaluation: their sensitivity, specificity and cost. *Nutrition Monitoring and Assessment* (eds. Gopaldas, T. and Seshadri, S.). Oxford University Press, Delhi, p.22

Taneja, M.K., Sandal, J. and shukla, P.L. 1978. Health status of urban school children in Western U.P. *Indian J. Pediatrics* **45**:339

Tanner, J.M. 1986. Sequence, Tempo and Individual variation in the growth and development of boys and girls, aged twelve to sixteen. *Nutr. Abs. Rev.* **52**(6):132

Thimmayamma, B.V.S. and Rau, P. 1996. Dietary Assessment as part of Nutritional Status. *Textbook of Human Nutrition* (eds. Bamji, M.S., Rao, N.P. and Reddy, V.). Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, p.125-135

Trowell, H.C. 1976. Definition of dietary fibre and hypothesis that it is a protective factor in certain diseases. *Am. J. Clin. Nutr.* **26**:417-427

Tsui, J.C. and Nordstrom, J.W. 1990. Folate status of adolescents: effect of folic acid supplementation. *J. Am. Dietet. Assoc.* **90**(11):1551-1556

Varalakshmi, B., Nair, G., Reddy, P.V.V. and Pandey, S.C. 1998. 'Arka Suguna': New multicut amaranth. *Indian Hort.* **42**(4):14-15

Vijayalakshmi, P. and Selvasundari, S. 1983. Relationship between iron deficiency anamia and energy expenditure. *Indian J. Nutr. Dietet.* **20**(4):113

Vijayaraghavan, K. 1987. Anthropometry for assessment of nutritional status. *Indian J. Pediatrics* **54**(4):511-520

Vijayakumar, M. and Shunmugavelu, K.G. 1985. A comparison on the amino acid composition of leaves and seeds of certain Amaranthus types. *Amaranth News L.* **1**:3

*Vizcaino, C.C., Vizcaino, G., Ewald, M.D., Vizcaino, M.A. and Guerra, E.T. 1995. Concentration of haemoglobin and nutrients in middle class adolescents. Relationship to academic achievement. *Investigation Clin.* **36**(3):117-130

*Waterlow, J.C. 1972. Classification and definition of protein calorie malnutrition. *Br. Med. J.* **3**:566-569

Weisell, R.C. and Francois, P.S. 1982. Reference weight for height standards - An easier approach for computerisation. *Food and Nutrition* (FAO) **8**(1):12-18

*WHO. 1979. *Nutritional anaemia.* Nutritional anaemia a brief for policy makers, ACC/SCN-NSZ

Wills, R.B.H., Wong, A.W.K., Scriven, F.M. and Grunfield, G.H. 1984. Nutrient composition of chinese vegetables. *J. Agric. Fd Chem.* **32**(2):413-416

*Widhalm, K., Brubachu, G. and Christella, S. 1986. Vitamin status of healthy adolescents 11 to 17 years old. Data from a longitudinal stury. *Monatsschrift-fur-Kinduheilkunde* **134**(6):408-411

Worthington, W. 1988. Nutrition throughout life cycle. *Nutrition in Adolescence.* Times Mirror/Mosky College Publishing, USA p.307

Wright, L.S. 1984. Physiological development in adolescence. *Nutrition in Adolescence* (ed. Mohan, K. and Ress, J.M.). Times Mirror/Mosky College Publishing, USA. p.165

* Original not seen

APPENDICES

APPENDIX-I

Interview schedule to elicit information on the food consumption pattern in the institutions.

1. Name of the Institution :

2. Head of the Institution :

3. Food habit : Veg / Non veg:

4. Staple food :

5. Frequency of use of various foods.

Food items	Frequency of use						
	Daily	Weekly			Monthly once	Occasionally	Never
		1	2	3 4			
Cereals							
Pulses							
Green leafy vegetables							
Roots and tubers							
Fruits							
Milk and milk products							
Egg							
Fats and oils							
Sugar							
Jaggery							
Spices and Condiments							
Others (specify)							

6. Do you maintain account for food expenditure: Yes / No.

i) If yes, in what form? : Written / Memory

ii) Daily / Weekly / Monthly

7. Details regarding meal planning

i) Do you plan your meals in advance? : Yes / No.

ii) If yes, what is the basis for planning?

Money availability

Total requirement of the inmates

Likes and dislikes of the inmates

Food availability

Others

iii) No. of meals per day : 1/2/3/more than 3

iv) Do you maintain specific time schedule : Yes / No.
for taking food?

Specify with reasons

8. Do you use boiled water for drinking? : Yes / No.

9. Dou you give equal importance for the
inmates in food distribution : Yes / No.

i) If no, what is the order of importance?

Order	Reason
1.	
2.	
3.	
4.	
5.	

10. Details regarding cooking of foods

i) How many times do you cook meals in a day: Once / twice / thrice / more than thrice

ii) Who does the cooking?

iii) What is the cooking device used?

Smokeless chullah / Ordinary chullah / Gas stove / Kerosene stove / Heater

iv) Cooking methods followed

Food item	Boiling	Absorption	Straining	Steaming	Frying		Baking	others
					Deep	shallow		
Cereals								
Pulses								
Other vegetables								
Leafy vegetables								
Fruits								
Meat								
Fish								
Egg								
Milk and Milk products								
Others, (specify)								

iv) Do you eat any raw foods? : Yes / No.

If yes, specify

11. Details of food preservation

i) Do you preserve any foods in your institution? : Yes / No.

ii) If yes, specify

No	Foods preserved	Method used	Storage period	Problems encountered
1)	Cereals			
2)	Pulses			
3)	Vegetables			
4)	Fruits			
5)	Milk			
6)	Meat			
7)	Fish			
8)	Others			

iii) Do you buy any preserved food from outside? Yes / No.

If yes, specify

12. Foods given during special conditions / occasions

i) Do you give special foods during diseased condition? Yes / No.

ii) If yes, specify

iii) Do you prepare any food items on special occasions? Yes / No.

iv) If yes, specify

APPENDIX-II

SCORE CARD FOR ORGANOLEPTIC EVALUATION OF AMARANTH RECIPES

Name & address:

Date :

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Appearance																					
Very good	5																				
Good	4																				
Fair	3																				
Satisfactory	2																				
Poor	1																				
Colour																					
Very good	5																				
Good	4																				
Fair	3																				
Satisfactory	2																				
Poor	1																				
Flavour																					
Very good	5																				
Good	4																				
Fair	3																				
Satisfactory	2																				
Poor	1																				
Texture																					
Very good	5																				
Good	4																				
Fair	3																				
Satisfactory	2																				
Poor	1																				
Taste																					
Very good	5																				
Good	4																				
Fair	3																				
Satisfactory	2																				
Poor	1																				

Signature

APPENDIX-III

AMARANTH RECIPES SELECTED AFTER ORGANOLEPTIC EVALUATION

i) Cheera minced meat thoran

Ingredients

Cheera	- 100g
Meat	- 50g
Coconut	- 50g
Green chilly	- 5g
Small onion	- 10g
Ginger (minced)	- ½ tsp
Mustard seed	- 1/8 tsp
Curry leaves	- 5 – 6
Pepper powder	- ½ tsp
Coriander powder	- 2 tsp.+.1 tsp
Turmeric powder	- ¼ tsp + ¼ tsp
Cloves	- 2
Cinnamon	- ½ inch piece
Oil	- 1 to 2 tsp
Salt	- to taste

Procedure

1) Steam minced meat for 10 minutes along with 2 tsp coriander powder, ¼ tsp turmeric powder, pepper powder, salt and minced ginger.
2) Mince onion, green chilly and cheera
3) Grind coconut along with 1 tsp coriander powder ¼ tsp turmeric powder, clove and cinnamon
4) Heat oil in a frying pan. Add mustard seed followed by minced onion, green chilly and curry leaves.
5) When the onion turns light brown, add the coconut and salt and mix well. Add minced cheera, cover and cook on a very slow fire, until the cheera is cooked well (Add 1-2 tbsp water if necessary).

6) Add the steamed meat mix well and remove from fire.

ii) Cheera thoran

Ingredients

Cheera	- 50 g
Coconut scraping	- 20 g
Mustard	- 1/8 tsp
Small onion	- 3 tsp
Chilli powder	- ½ tsp
Oil	- 2 tsp
Salt	- to taste

Procedure

1) Heat oil in a frying pan. Add mustard seeds followed by onion, when onion turns light brown add chilli powder and salt.
2) Then add coconut scrapings and cheera. Cover the pan and cook it on a low flame for 5-10 minutes.

iii) Cheera pachadi

Ingredients

Cheera	- 50 g
Coconut scrapings	- 2 tbsp
Green chilli	- 1
Ginger (minced)	- ¼ tsp
Small onion	- 4
Garlic	- 2 flakes
Mustard seed	- 1/8 tsp
Minced onion (small)	- 2 tsp
Curry leaves	- 3-4
Oil	- 2 tsp
Curd	- ½ cup
Salt	- to taste

Procedure

1) Mince cheera
2) Grind coarsely coconut, chilli, ginger, onion and garlic
3) Heat oil. Add mustard seeds followed by minced onion and curry leaves
4) When onion turns light brown, add the ground mixture, mix well. Add 2 tbsp water and salt to taste.
5) Add the minced cheera and mix well. Cover and cook on a slow fire until cheera is tender (Add more water if necessary)
6) Remove from fire. Add beaten curds and mix well. Add salt if necessary.

iv) Cheera Curry

Ingredients

Cheera	- 100g
Green chilly	- 2 Nos.
Chilly powder	- ½ tbs
Coriander powder	- 1 tbs
Tamarind	- 1 lemon size
Mustard	- ½ tsp
Cumin seed powder	- ½ tsp
Asafoetida	- to taste
Water	- 1 cup
Salt	- to taste
Oil	- for seasoning

Procedure

1) Cook cheera for 5 minutes
2) Mix green chillies and salt. Add chilly powder, coriander powder, cumin seeds powder and asafoetida.
3) Add tamarind juice to this mixture and cook well.
4) Season it with mustard, red chillies and curry leaves

v) Cheera egg thoran

Ingredients

Cheera	- 50 g
Egg	- 1
Coconut	- 1 tbsp
Green chilli	- 1
Small onion	- 2
Garlic	- 1 flake
Mustard seed	- 1/8 tsp
Small onion (minced)	- 1 tsp
Curry leaves	- 2-3
Oil	- 2 tsp
Salt	- to taste

Procedure

1) Wash cheera and mince
2) Beat egg lightly and add salt
3) Grind coarsely items 3-6 (coconut, chilly, onion and garlic)
4) Heat oil in a frying pan, add mustard seeds followed by minced onion and curry leaves
5) When the onion turns light brown, add the ground coconut mixture blend well
6) Add beaten egg. Allow it to coagulate (1-2 minutes) stir with a fork until the egg is cooked (The cooked egg particles should be the size of the coconut scrapings)
7) Add cheera and mix well. Add 1 tbsp water and salt to taste. Cover and cook over a slow flame until cheera is tender. Remove from fire.

vi) Cheera dhal maseel

Ingredients

Cheera	- 20g
Dhal	- 20g
Green chilly	- 1
Ginger (minced)	- ¼ tsp
Onion	- 1
Mustard	- 1/8 tsp
Curry leaves	- 3 to 4

Oil	- 1 tbs.
Salt	- to taste

Procedure

1) Cook Dhal in excess water (when cooked it should have a semi liquid consistency)
2) Mash Dhal. Add salt.
3) Mince cheera and steam until tender (about ten minutes)
4) Add the cooked cheera to dhal and mix well.
5) Mince onion, green chilly and ginger.
6) Heat oil in a frying pan. Add mustard seeds followed by the minced onion green chilly, ginger and curry leaves.
7) When the onion turns golden brown add the dhal cheera mixture. Mix well and remove from fire.

vii) Cheera vada

Ingredients

Cheera	- 100g
Bengal gram flour	- 100g
Big onion	- 1
Green chillies	- 4
Chilly powder	- ½ tsp
Jeerakam	- ½ tsp
Salt	- to taste
Oil	- for frying

Procedure

1) Heat oil in a pan. Fry onion, jeerakam and chillies
2) Add cheera (only leaves) to it and cook for 5 minutes
3) Add Bengal gram flour slowly and mix well by adding water (if needed) to get a proper consistency
4) Shape it into vada and fry it in oil

viii) Cheera green gram thoran

Ingredients

Cheera	- 100 g
Sprouted green gram	- 50 g
Coconut scrapings	- 2 tbsp
Small onion	- 20 g
Chilly powder	- 2 tsp
Turmeric powder	- ½ tsp
Mustard	- 1/8 tsp
Salt	- to taste

Procedure

1) Cook sprouted green gram in excess water. Add salt and cheera to it and cook for five minutes.
2) Heat oil in a frying pan, add mustard seed followed by minced onion, chilly powder, turmeric powder and coconut scrapings.
3) When the onion turns golden brown add the sprouted green gram cheera mixture. Mix well and remove from fire.

ix) Cheera cutlet

Ingredients

Cheera	- 100g
Potato	- 50g
Onion	- 20g
Green chilly (minced)	- 1 tsp
Ginger (minced)	- ½ tsp
Egg white	- 1 egg's
Bread Crumps	- 25 g
Salt	- to taste
Oil	- for frying

Procedure

1) Mince Cheera and steam until well cooked
2) Boil potato and mash well
3) Heat 1½ tsp oil in a frying pan and sauté minced onion, ginger and green chillies. When the onion turns golden brown add the cooked cheera and mix well.
4) Remove from fire and add the mashed potato. Add salt and mix well. Add 1tsp bread crumbs and mix well.
5) Divide the mixture into equal parts. Shape each into cutlets.
6) Dip in beaten egg white and roll in bread crumbs.
7) Deep fry until golden brown

x) Cheera chappathi

Ingredients

Wheat flour	– 50g
Cheera (minced)	– 25g
Potato	- 25g
Green chilli (minced)	- ¼ tsp
Onion (minced)	- 10 g
Oil	- 3 tsp
Salt	- to taste

Procedure

1) Boil potato and mash
2) Steam cheera until cooked (about ten minutes)
3) Heat 2 tsp oil in a frying pan and fry minced onion and chilly. When onion turns light brown, add steamed amaranth and mix well. Remove from fire.
4) Add this mixture to the wheat flour and mix. Add mashed potato, salt and sufficient water to make a dough and knead well.
5) Divide in to balls, roll out into chappathi
6) Heat tawa and prepare chappathi

Source: Abraham, S. 1997. *Nutrition in Everyday Life*. Keerthi Publishing House Pvt Ltd. p 47-57

APPENDIX-IV

Schedule for individual food consumption survey – weighment method

Date:_____

Name of the Institution:

Name of the subject:

Age of the subject:

Name of the meal	Menu	Food consumption		
		Weight of Raw ingredients used by the institution	Weight of cooked ingredients used by the institution	Weight of cooked ingredients used by the individual
Breakfast				
Lunch				
Evening tea				
Dinner				
Others				

APPENDIX-V
CLINICAL ASSESSMENT SCHEDULE

	Signs known to be value in nutrition surveys
1) Hair	- Lack of lusture - Thinness and sparseness - Strightness - Dyspigmentation - Flag sign - Easy pluckability
2) Face	- Diffuse depigmentation - Naso-labial dyssebacea - Moon face
3) Eyes	- Pale conjunctiva - Bitot's spots - Conjunctival xerosis - Corneal xerosis - Keratomalacia - Angular palpebritis
4) Lips	- Angular stomatists - Angular scars - Cheilosis
5) Tongue	- Oedema - Scarlet and raw tongue - Magenta tongue - Atrophic papillae
6) Teeth	- Mottled enamel - Dental caries
7) Gums	- Spongy, bleeding gums
8) Glands	- Thyroid enlargement - Parotid enlargement
9) Skin	- Xerosis - Follicular hyperkeratosis – types 1 and 2 - Petechiae - Phynoderma - Pellagrous dermatosis - Scrotal and vulval dermatosis

10) Nails	- Koilonychia
11) Subcutaneous tissue	- Oedema - Amount of subcutaneous fat
12) Muscular and skeletal systems	- Muscle wasting - Craniotabes - Frontal and parietal bossing - Epiphyseal enlargement (tender or painless) - Beading of ribs - Persistently open anterior fontanelle - Knock-knees or bow-legs - Diffuse or local skeletal deformities - Deformities of throrax (selected) - Musculo-skeletal haemorrhages

Others(Specify)

Source : Jelliffe, D.B.1966.*The Assessment of the Nutritional Status of the Community.* World Health Organization. Geneva

APPENDIX-VI

ANOVA on difference in height, body weight, Hb level, RBC count, PCV and functional performance before and after the study, between control, 2/3rd RDA and full RDA groups

HEIGHT (Boys)

	Degree of freedom	Sum of squares	Mean squares	F value	Prob	CD
Between	2	3.882	1.941	4.385	0.016	0.413
Within	57	25.235	0.443			
Total	59	29.117				

HEIGHT (Girls)

	Degree of freedom	Sum of squares	Mean squares	F value	Prob	CD
Between	2	5.263	2.632	1.241	0.2969	0.903
Within	57	120.891	2.121			
Total	59	126.154				

BODY WEIGHT (Boys)

	Degree of freedom	Sum of squares	Mean squares	F value	Prob	CD
Between	2	14.925	7.463	3.794	0.0284	0.869
Within	57	112.127	1.967			
Total	59	127.052				

BODY WEIGHT (Girls)

	Degree of freedom	Sum of squares	Mean squares	F value	Prob	CD
Between	2	1.322	0.661	4.839	0.0114	0.229
Within	57	7.788	0.137			
Total	59	9.110				

Hb LEVEL (Boys)

	Degree of freedom	Sum of squares	Mean squares	F value	Prob	CD
Between	2	7.202	3.601	50.847	0.000	0.165
Within	57	0.037	0.071			
Total	59	11.239				

Hb LEVEL (Girls)

	Degree of freedom	Sum of squares	Mean squares	F value	Prob	CD
Between	2	6.808	3.404	35.142	0.000	0.193
Within	57	5.522	0.097			
Total	59	12.330				

RBC COUNT (Boys)

	Degree of freedom	Sum of squares	Mean squares	F value	Prob	CD
Between	2	1.261	0.630	35.407	0.000	0.083
Within	57	1.015	0.018			
Total	59	2.276				

RBC COUNT (Girls)

	Degree of freedom	Sum of squares	Mean squares	F value	Prob	CD
Between	2	1.577	0.786	21.775	0.000	0.372
Within	57	2.065	0.036			
Total	59	3.642				

PCV (Boys)

	Degree of freedom	Sum of squares	Mean squares	F value	Prob	CD
Between	2	53.264	26.632	27.336	0.000	0.612
Within	57	55.531	0.974			
Total	59	108.796				

PCV (Girls)

	Degree of freedom	Sum of squares	Mean squares	F value	Prob	CD
Between	2	29.382	14.691	6.828	0.0022	0.909
Within	57	122.637	2.152			
Total	59	152.019				

FUNCTIONAL PERFORMANCE (Boys)

	Degree of freedom	Sum of squares	Mean squares	F value	Prob	CD
Between	2	799.729	399.865	100.910	0.000	1.234
Within	57	225.867	3.963			
Total	59	1025.597				

FUNCTIONAL PERFORMANCE (Girls)

	Degree of freedom	Sum of squares	Mean squares	F value	Prob	CD
Between	2	748.046	374.023	30.170	0.000	2.182
Within	57	706.636	12.397			
Total	59	1454.682				

EFFECT OF AMARANTH ON THE HEALTH AND NUTRITIONAL PROFILE OF ADOLESCENTS

By

SUMAN. K. T.

ABSTRACT OF THE THESIS

Submitted in partial fulfillment of the requirement for the degree of

Master of Science in Home Science

(FOOD SCIENCE & NUTRITION)

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF HOME SCIENCE

COLLEGE OF HORTICULTURE

VELLANIKKARA, THRISSUR - 680 656

Kerala, India

2000

ABSTRACT

The present study entitled 'Effect of amaranth on the health and nutritional profile of adolescents' was conducted among 120 adolescents, selected from juvenile home and orphanage in Trichur district on the basis of occurrence of anaemia. The selected samples were divided into three groups viz., control, 2/3rd RDA and full RDA groups, consisting of 40 adolescents in each group.

Food consumption pattern of the inmates revealed that all were non-vegetarians and rice formed their staple food. The daily used food items by the inmates of the institutions included cereals, pulses, roots and tubers, other vegetables, milk, fats and oils, sugar and spices. Advanced meal planning was done in both the institutions.

The acceptability study of amaranth recipes showed that they were acceptable with respect to different quality parameters. Among the recipes, cheera minced meat thoran obtained the highest score in the acceptability study and cheera pittu scored the lowest. The 10 recipes which obtained the highest total scores were selected for the feeding trial.

The nutrient analysis of fresh amaranth and amaranth recipes showed that the protein content of most of the recipes were higher than the fresh amaranth. All the recipes had higher starch and soluble carbohydrate content than fresh amaranth. The fibre content of cheera thoran, cheera vada, cheera curry and cheera green gram thoran were higher than the fresh and cheera thoran and cheera curry had higher iron content compared to fresh amaranth. All the recipes showed lower content of calcium, β carotene and vitamin C compared with fresh amaranth.

Assessment of the nutritional status of adolescents after the supplementation study revealed significant increments in anthropometric measurements, haematological indices and mean scores of the functional performance test in all the three groups with greater increase in full RDA and 2/3rd

RDA groups compared to control group. The distribution of adolescents into various nutritional status based on weight for height and body mass index revealed changes in nutritional status irrespective of the groups.

The most common nutritional deficiency disease observed among adolescents was anaemia, which was reduced in all the three groups after the supplementation study. Dental caries was also observed among adolescents irrespective of the group.