UTILIZATION OF CRUDE PALM OIL FOR DEVELOPMENT OF VIT. A RICH SUPPLEMENTARY FOODS

By

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Thesis submitted to the Chaudhary Charan Singh Haryana Agricultural University in partial fulfilment of the requirements for the degree of:

MASTER OF SCIENCE

in

FOODS AND NUTRITION

I.C. College of Home Science
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2001

A petal from this small flower

to the feet of my

Amma Nanna

Who made me fragrant

Who gave wings to my dreams

Who gave a perfect tune to my music

Who made me accept both victory and strife of life

Who gave me the spirit to stand through my endeavours

Who made me understand the thoughts of millions

CERTIFICATE - I

This is to certify that this thesis entitled, "Utilization of crude palm oil for development of vit. A rich supplementary foods" submitted for the degree of M.Sc. in the subject of Foods and Nutrition of the Chaudhary Charan Singh Haryana Agricultural University, is a bonafide research work carried out by Ms T. Supraja under my supervision and that no part of this thesis has been submitted for any other degree.

The assistance and help received during the course of investigation have been fully acknolwedged.

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CERTIFICATE - II

This is to certify that this thesis entitled, "Utilization of crude palm oil for development of vit. A rich supplementary foods" submitted by Ms T. Supraja to the Chaudhary Charan Singh Haryana Agricultural University in partial fulfilment of the requirements for the degree of M.Sc., in the subject of Foods and Nutrition, has been approved by the Student's Advisory committee after an oral examination on the same.

MAJOR ADVISOR 16/2/2007

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DEAN, POSTGRADUATE STUDIES

ACKNOWLEDGEMENTS

In this stage of great ecstasy and felicity, I express my deep and profound sense of gratitude to my Major Advisor Dr. (Mrs.) Salil Sehgal, Professor, Department of Foods and Nutrition, for her sustained guidance, encouragement, affectionate behaviour, excellent cooperation, supervision, constructive criticism and magnanimous help during the course of this investigation and preparation of this manuscript.

My heartfelt and fervent thanks are also due to members of my advisory committee. Dr. (Mrs.) Saroj Dahiya, Department of Foods and Nutrition, Dr. (Mrs.) Shashi Madan, Department of Biochemistry, Dr. R.C. Hasija, Department of Mathematics and Statistics, Dr. (Mrs.) Binoo Sehgal, Department of Family Resource Management, for their continuous interest, advice, constructive comments and help rendered at various stages of this study.

I am also indebted to Dr. (Mrs.) Neelam Khetarpaul, Professor and Head, Department of Foods and Nutrition for her everwilling help.

I owe my abundant thanks to entire faculty members and students of Govt. Primary School, Canal Colony and subjects of my study, without their help and cooperation, the study would not have materialized.

I wish to thank Mr. Brahmaji Rao Mr. Chandrashekhar. APOILED and Ms Nagamaneswari, T., M.Sc. (HCU) for providing technical guidance during the course of study.

It is a great pleasure for me to acknowledge the untiring help and support I received from my friends.

No words of mine can express my deep sense of love and gratitude to my grand parents, parents (Smt. Ramulamma and Sri Penchalaiah), sisters, brothers, uncles, aunts and cousins for the moral support, love and encouragement provided during the entire course of study.

It would be very mean act on my part if do not thank teaching, research and non-teaching staff of the Department of Foods and Nutrition for their timely help.

I am also grateful to Dr. R.P. Singh for analysing the data. I am highly indebted to Mr. Subhash Chandra for his meticulous typing.

Last but not the least, I thank ICAR, New Delhi for providing financial assistance in the form of Junior Research Fellowship.

Errors and omissions are mine

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January , 2001

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CHAPTER- 1

INTRODUCTION

Vitamin A deficiency is a systemic disease with most prominent manifestation occurring in the eye. It is the most widespread nutritional disorders causing blindness in developing countries among vulnerable groups, especially pre-school children (Vijayaraghavan *et al.*, 1984). Severe forms of the deficiency result in corneal blindness and the incidence is particularly high in young children of poor communities. Majority of the children suffer from subclinical deficiency of vitamin A without signs of xeropthalmia, with serum retinol levels below 20 μg/dl.

Vit. A deficiency is associated with increased morbidity and mortality in children (Sommer *et al.*, 1983, 1984, Milton *et al.*, 1987) and may predispose to different types of respiratory infections (Solon *et al.*, 1978; Tielsch *et al.*, 1986; Desole *et al.*, 1987; Sommer *et al.*, 1987; Bloem *et al.*, 1990). Prospective community-based studies confirm that there is an increased risk of respiratory disease in children with vit. A deficiency (Sommer *et al.*, 1984; Milton *et al.*, 1987; Vijayaraghavan *et al.*, 1990; Dibley *et al.*, 1996). Vit. A deficiency renders young children vulnerable to diarrhoea and to severe measles and high mortality (Markowitz *et al.*, 1989; Butler *et al.*, 1993). Although vit. A deficiency

increases the risk of infectious diseases, the interaction is bidirectional such that infections can lead to vit. A deficiency. Diarrhoea, respiratory infections, measles, chickenpox and HIV infection are all associated with the development of vit. A deficiency (Campos *et al.*, 1987; Sommer *et al.*, 1987; Rahman *et al.*, 1996; Semba, 1997)

According to National Nurtition Monitoring Bureau (NNMB) Survey (1988-90) 0.5-1.0 per cent population of children, in seven states of India continue to show clinical signs of vit. A deficiency. Sommer (1989) reported that 25-50 million children world wide may be suffering from the physiologic consequences of vit. A deficiency. Five million of them are developing xeropthalmia and of these annually 2,50,000 to 5,00,000 go blind. About half a million children in India become blind every year as a result of vit. A deficiency (Reddy and Vijayaraghavan, 1991). More than 124 million children in the world were estimated to be affected by vit. A deficiency and predicted 1 to 2.5 million deaths are preventable by improvement of vit. A nutriture (Humphrey *et al.*, 1992). Vit. A deficiency continues to be a major public health problem in many parts of the world including India, and the Nutrition Foundation of India is exploring the natural sources available in the country to combat the disorder through dietary improvement (Gopalan *et al.*, 1992). Massive oral therapy with 60,000 µg vit. A to preschool children is one of the measure taken to combat vit A. deficiency though it has its own limitations (Gopalan, 1990). Improved dietary intake of locally available β-carotene rich foods has been found to be as effective as synthetic vit A, in

combating deficiency (Hussein and Tohamy, 1989; Lala and Reddy, 1970).

Vitamin A is unique structurally, essential nutritionally, elegant in its photo-receptor role, and yet is tantalizingly mysterious in its other biological involvements. Vitamin A is only present in animal foods. However, it can be made in the body from yellow provitamin A i.e., carotenoids, found largely in foods of plant origin. Among 500 known carotenoids, 50-60 possess pro-vitamin A activity. The most important pro-vitamin A is β-carotene and this is converted to vit. A in the body.

Food sources of carotenoids which are abundantly found in most developing countries includes leafy and yellow vegetables and citrus fruits. But due to faulty cooking methods and low socio-economic status of most of the population, the actual availability of β-carotene is decreasing. In case of children, the leafy vegetable products are not appreciably accepted beside the fact the rapid growth and development during early childhood demands greater intake of such nutrients. This higher requirement of children is not adequately met through cereal based conventional diets. The poor diets and inadequate nutrient intake are reflected in poor nutritional status of children which is the major cause of vit. A deficiency.

In India, vegetable oils are the main sources of dietary fat. These are the excellent sources of energy and fat soluble vit. A, D, E and K. They contribute to palatability of the diets and also reduce the bulk of food we take. The most important function of dietary fat is to provide the essential fatty acids (EFA) to the body. The EFA are components of

membranes of living cells. They are also used by the body to make prostaglandins involved in a large variety of vital physiological functions. They also play a role in immunity.

There is a wide range of sources of edible oils in our country such as groundnuts, mustard seeds and rapeseeds which constitutes about one-third of the total supply (Rao *et al.*, 1988). Since vegetable oils production in India is not sufficient to meet the growing demands of population, the government has been importing several kinds of vegetable oils from other countries.Studies on blended oils began in India in late 1980's mainly to meet the edible oil shortages, and to ease the pressure on one or two individual oils whose shortages led to sky-rocketing prices (Rao, 1988). Newer non conventional oils were explored for blending with commonly consumed vegetable oils.

The unconventional oils like red palm oil, Palm oil, Palm-olein oil, ricebran oil, sesame oil, etc., are nutritionally beneficial and are more preferable for blending. Apart from being hypocholesterolemic (NIN Annual Report, 1986-87), these oils have additional advantages due to their non-fatty components like carotenes, tocopherols, tocotrienols and sesamolin group of compounds.

Cooking oils differ in their nutritional importance based on their composition, especially, the fatty acid content. Commonly consumed vegetable oils like groundnuts, safflower, sunflower and sesame oils are rich in polyunsaturated fatty acids (PUFA), whereas animal foods/fats like lard, tallow, butter, etc., are rich in saturated fatty acids (SFA). The quantity

and quality of dietary fat intake is responsible for obesity and various killer diseases including cardiovascular diseases and certain forms of cancer. It was earlier thought that PUFA lowers the blood cholesterol level which is associated with cardiovascular risk. But, later it was found that PUFA produce free radicals in the body, which hasten the ageing process and even induce cancer.

Recently, newer carotene rich foods that offer considerable promise were discovered. Some of them are Red palm oil, Spirulina, Buriti, Bhakri, Santi, Pingu, some oil seeds, *Dunaliella* sp. *Marunggay* leaves and *Blakeslea* sp.Among them. Red palm oil (RPO) (*Elaeis guineensis*) the unrefined, unbleached version of the more conventional palm oil (PO) is the only vegetable oil which contains a very high quantity of carotenoids (Maclellan, 1983) in the unsaponifiable non-glyceride fraction (Goh, *et al* 1985). It is yet unfamiliar to the Indian consumer. Systemic studies have been carried out at NIN, Hyderabad on the nutritional and safety aspects of RPO and reported it to be completely safe and useful in controlling nutritional blindness among children (Manorama, 1994). The total carotenoids content of RPO has been reported to range between 500 to 700 µg/g with 85-90 per cent constituting of α and β -carotenes, the most active precursors of vit. A (Ng and Tan, 1988). Palm kernel oil contains 0.30 µg β–carotene per g of oil.

Crude palm oil (CPO) which is also known as red palm oil (RPO) is unique among all vegetable oils and can be classified as an unconventional oil. It is bright red orange in colour due to its carotenoid content, which

varies with the degree of ripeness and the genotype of the fruit. RPO is obtained from the mesocarp of the fruit of the oil palm (*Elaeis guineensis*) which originated in the west coast of Africa. After the 15th century, it was introduced to other parts of Africa, South East Asia, Malaysia and Latin America.

Cultivation of oil palm was started in India by Oil Palm India Limited under the Technology Mission on Oilseeds (TMO) which was set up in the year 1986 to meet vegetable oil shortages in India (Abraham, 1988). The committee identified about 2.5 lakh hectares in Andhra Pradesh (Krishna East and West Godavari districts), Tamil Nadu (Nagarcoil), Karnataka (Cauvery, Thungabhadra, Ghattaprabha, Mallaprabha Areas) 1.0 Lakh hectares in Orissa (Berhampore, Ganjam, Koraput) and about 0.5 Lakh hectares each in Assam, Tripura and other Eastern states for cultivation of oil palm.

The technology for extraction of edible grade crude palm oil or red palm oil was developed in India by Regional Research Laboratories (RRL-CSIR) at Trivendrum, Kerala, in a joint venture with the central plantation crops Research Institute (CPCRI-ICAR) (Armugan *et al.*, 1989). Indigenously produced red palm oil contains around 550 µg/g of total carotenoids (Armugan *et al.*, 1989) and 375 µg/g of β–carotene (Manorama and Rukmini, 1991).

RPO, besides providing calorie density to the diet is extremely rich in carotenoids and tocopherols. They form the major portion of the non-glyceride fraction in RPO.β–carotene is the most active precursor of vit.

A which is important for vision, health of mucous membranes, skin growth of bone and reproduction. Recently β–carotene was found to be anti-carcinogenic (Stahelein *et al.*, 1991). It is an antioxidant that destroys singlet oxygen and free radicals.

Chemical analysis of RPO indicates that it has 50 per cent saturated, 40 per cent mono unsaturated, and 10 per cent polyunsaturated falty acids. It contains 1,000 µg/g of tocopherols and tocotrienols (Manorama 1994). The beneficial effects of RPO carotenoids and tocopherols have been strongly established (Sundaram, 1989; Qureshi *et al.*, 1991a). Using RPO would help to solve the problem to a great extent expecially in areas where vit. A deficiency is more prevalent among children.

Scope of the present work

Natural food sources of carotenoids are bound to assume powerful significance in the immediate future as potential intervening factors in major human deseases. In this context, RPO is the richest natural food source to provide carotenoids in their most efficient liquid soluble form, and in far larger quantities than in any existing vegetable sources. With an expected potential of 1.2 million tons annually in the next decade, the amount of carotenes that will be available in India itself amount to about 5 to 7 lakh kg. Hence, promotion of commercial production and consumption of RPO is an important immediate priority. Moreover, evidences are there on the potential health benefits of RPO and its safety for human consumption (Manorama and Rukmini, 1991b; Manorama *et al.*, 1989). Sensory evaluation of Indian food prepared with the oil has

shown that RPO was well accepted and can be used in supplementary feeding programmes in preschool children (Manorama and Rukmini, 1992b; Devadas *et al.*, (1992) indicated that Indian school children fed supplementary snacks prepared with RPO for 60 days and 10 weeks, respectively resulted in significant increases in serum retinol levels as well as an increased liver retinol store, suggesting the ready bio-availability of β–carotene (Rukmini, 1994).

The carotenoid content of RPO makes it an ideal vehicle for vit. A prophylaxis programme to vulnerable groups. But information available is not on the protective effect of RPO in combating vit. A deficiency. Hence, the present study has been designed to evaluate the protective effect of RPO in comparison with massive vit. A dose in combating vit. A deficiency. It has been established that 2,00,000 I.U. of massive vit. A dose to preschool children and 1,00,000 I.U. to school children have protective effect for 6 months . Keeping in view the advantages of red palm oil , the present investigation was planned with the following specific objectives:

1. To develop vitamin A rich supplementary foods using crude palm oil.
2. To evaluate developed products for nutritional and organoleptic characteristics.
3. To study the shelf life of the developed products.
4. To study the effect of feeding developed supplementary foods on nutritional status of children.

CHAPTER - 2

REVIEW OF LITERATURE

This chapter provides an overview of the prevalence of vitamin A deficiency; intervention strategies to combat vitamin A deficiency, and promising sources of β-carotene, their physico-chemical properties, nutritional aspects, heat and storage stability of RPO are reviewed at length. The literature available on the above aspects has been classified and presented under the following sub-heads:

2.1 Prevalence of vitamin A deficiency

2.2 Intervention strategies to combat vitamin A deficiency

2.3 Promising source of β-carotene

2.4 Crude palm oil, its composition and quality

2.5 Fatty acid composition of crude palm oil

2.6 Carotenoids in crude palm oil

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2.1 Prevalence of vitamin A deficiencey

Vitamin A deficiency is wide spread in many countries of South East Asia. About 2,00,000 cases of blindness among children were reported annually in less industrialised parts of the world (Sommer *et al.*, 1981).

India has an estimated population of 86 crores with an under five year population of 21 per cent among whom approximately 80,000 corneal and 40,000 blind cases are reported annually (Devadas *et al*., 1984).

In many developing countries vit. A deficiency occurs among vulnerable groups especially pre-school children which constitute a major public health problem (Vijayaraghavan *et al.*, 1984).

The deficit in food intake were replicated in the nutrient intake i.e. energy, protein, vit. A riboflavin, iron and folic acid (Bai *et al.*, 1984).

According to Gopalan *et al.*,(1992), major nutritional problems are PEM, vit. A deficiency and iron deficiency anaemia.

According to National Nutrition Monitoring Bureau (NNNB) Survey (1988-90) 0.5-1.0 per cent population of children situated in seven states of India continue to show clinical signs of vit. A deficiency.

It is estimated that 5 million children in Asian countries suffer from xerophthalmia, of which almost quater go blind (Sommer, 1989).

It has been reported that vit. A deficiency is resulting in blindness in more than 60 million children in the world (Vitamin A Report, 1990).

Kamgoankar *et al.* (1990) surveyed prevalence of vit. A deficiency in 366 Indian rural children (1-15 years old). The prevalence of vit. A deficiency signs was 24 per cent to 34 per cent. The adequacy of dietary intake of vit. A was 8 to 12 per cent when compared with RDA.

Surveys in different parts of India have shown that about 5-10 per cent of children have clinical signs of vit. A deficiency (Reddy, 1991a).

Severe forms of the disease involving cornea are seen almost frequently in chidren in the age group of 1-5 years (Reddy, 1991b).

There is a wide variation in the prevalence rates in preschool chidren ranging from 0.5 per cent in Kerala, 0.6 per cent in Tamil Nadu, 1.1 per cent in Karnataka, 0.3 per cent in Maharastra, 1.1 per cent in Orissa to 1 per cent in Andhra Pradesh (NFI, 1991).

NFI (1991) reported about 30,000 cases of corneal xerophthalmia in preschool children per year, of which nearly half would result in permanent blindness.

The diets consumed by a large majority of pre-school children are deficient in calories, proteins and several vitamins and minerals particularly vit. A, C, folic acid and iron (Drake, 1992; ACC/SCN, 1993).

Goyal [redacted] (1994) in a survey carried out on school going children (7-9 years old) in rural areas of Rohtak district revealed dietary intake of vit.A and vit. A rich foods GLV and animal food was much below RDA. Signs of vit. A deficiency were also reported in some of the children.

Susheela and Sehgal (1994) reported that vit. A intake was inadequate among rural as well as urban adolescent girls of Hisar district.

A baseline survey in Tamil Nadu reported high Xerophthalmic rates including night blindness (3.7%) bitot spots (7.2%) and total xerophthalmia rate 10.95 per cent. Biochemical data from the same survey indicated that 37.5 per cent had retinol levels <0.7 μmol/L.

Micronutrient malnutrition, particularly vit. A deficiency and iron deficiency anaemia poses a serious threat to the health of children, who are the most vulnerable segment of the Indian population (Vijayaraghavan, 1995). NFI (1998) reported that 25 per cent of the world total of 15 million blind live in India of whom, about a fifth can trace the origin to vitamin A deficiency.

2.2 Intervention Strategies to Combat Vit. A Deficiency

Vit. A works unequivocalcy, strategies for controlling and preventing vit. A deficiency range from medical interventions to improving vit. A rich food consumption in developing countries.

The need for prevention and control of this deficiency is stressed, because the deficiency shows hardly any symptoms at its preclinical stage, it has an insidious way of rapidly deteriorating to an irreversible state after a short and mild clinical course. So, in order to combat this deficiency WHO has recommended the periodic oral dosing approach.

The concept of delivering a single prophylactic dose of vit. A to children who may be at high risk of vit. A deficiency was first introduced more than two decades ago.

A study was conducted on serum vit. A levels after administering a single massive oral dose. Serum vit. A concentrations were determined from finger prick samples of blood from 128 children of 2 to 6 years age group. Ninety four of these children had received a massive oral dose of 100,000 μg of an oil preparetion of vit. A. Serum vit. A levels were estimated at 4 months, 1 year and 2 years after the dosing.

The results showed that serum vit. A levels were significantly higher in the experimentally group than in the controls as given below:

Controls (No vitamin given)	Vit. A values at different intervals after a single massive oral dose of 100,000 μg		
	4 months after	1 year after	2 years after
μg/100 ml	μg/100 ml	μg/100 ml	μg/100 ml
20.4±0.89 (34)	37.4±3.78 (13)	27.4±1.37 (57)	24.0±1.27 (24)
	* P<0.001	* P<0.001	* P<0.001

Mean ± S.E.
Number of subjects in parantheses
*Levels of significance against control

The highest values were seen at 4 months after dosing and the levels had dropped considerably at the end of one year, and still further at the end of two years. The values at the end of one and two years were, however, significantly higher than values in controls (P>0.001). The observation made here that serum levels were maintained at satisfactory levels for as long as a period of 4 months after a single dose and that the levels were higher than in controls, even at the end of two years, showed that the administered vitamin must have been stored in the liver (Susheela, 1969).

Oilseeds have double advantages of being good source of protein, rich source of calories because of their high oil content and rich source of β-carotene. These can be used as valuable protein, calorie and β-carotene rich supplements.

Another study was conducted to see the effect of a single massive dose of vit. A on serum and liver levels of the vitamin. Seven apparently normal children and eight who had been successfully treated for varying grades of protein-calorie malnutrition were given a single oral dose of 300,000 IU oil soluble vit.A palmitate after their initial plasma levels of the vitamin were determined. Six, nine and twelve months after the dosing, the plasma levels of vit.A were redetermined in some of the children.

The results showed that the initial level of serum vit. A in 15 children studied averaged 25.0 IU/100 ml (Table 1).

Table 2.1. Serum vit. A levels after a single massive oral dose of 300,000 IU in chidlren

Time interval	No. of subjects	Serum vit. A IU/100 ml[a]	No. of subjects with undetectable levels
Initial	15	25.0±4.1	3
Six months	13	90.0±15.2	0
After dosing 9-14 months	7	43.0±4.13	0

[a] Values are mean±SEM

In three of these children vit. A could not be detected in serum (less than 10 IU/100ml). Six months after the dose, the mean value was 90.0 IU/ 100 ml the level in every child being significantly higher than before the dose. Between 9 and 14 months after the supplement the mean value in seven of the children who could be followed up was 43 IU/100 ml, a value still significantly higher than the initial level, but considerably below the concentration seen at 6 months (Srikantia and Reddy, 1970).

A pilot study was conducted at Hyderabad where in a single dose of 300,000 IU of vit. A in oil was adminstered orally once a year to a large group of pre-school children. It was found that the incidence of vit. A deficiency was reduced by nearly 75 per cent. Plasma levels of vit. A estimated in a sub sample of these children showed that satisfactory concentration of vitamin was maintained till 6 months after the dose. In view of the tendency of plasma levels to decrease after 6 months and in order to reduce the risk of side effects due to hypervitaminosis A, it was recommended that the dose of the vitamin may be reduced to 200,000 IU but given once in 6 months.Since then, periodic administration of a large oral dose of 200,000 IU vit. A to pre-school chidlren in targeted high risk population groups has become the most widely practiced prevention groups has become the most widely practiced prevention strategy in the world.

The physiologic objective of periodic dosing is to maximise liver retinol reserves from a single large dose of vit. A with minimum risk of toxicity. Ingested retinol, from the large dose is absorbed through the small intestine and transported in association with chylomicrons to the liver, where it is stored primarily as retinol palmitate. Upon demand, hepatic vit. A is mobilized ,released into the circulation, complexed with transport proteins that are synthesized in the liver and delivered to epithelial membranes and other target tissues.

Supplementary programmes have been implemented in many countries including Bangladesh, India, Guatemala, Phillippines, Sri Lanka, Tanzania and Thailand. Many supplementation studies have been

conducted using synthetic vit. A as a means of combating the hazards of deficiency of this vitamin.

Supplementation of vit. A with a high dose oral capsule or liquid every six months for chidlren of 1-5 years old is the most common intervention, though smaller and more frequent doses are being tested. This high dose (200,000 IU) of vit. A (as opposed to a daily recommended dose of 1000 IU) is stored in the liver and provides adequate levels of vit. A for approximately six months.

A single massive dose of 2,00,000 IU of vit. A to children either in capsule or liquid form is extremely effective. It cures practically all cases of severe vit. A deficiency. Furthermore, it provides protection from xerophthalmia for 4-6 months after supplementation.

Gopaldas and Kapoor (1988) gave 2 lakh IU of vit. A palmitate to 219 boys and 175 girls (7-15 years old) for 2 months to all of whom showed one or more of clinical ocular signs of vit. A deficiency and came from underprivilaged groups in India. Within two months all signs showed improvement. Greatest response for night blindness and conjuctival xerosis was during third week and for Bitot's spots in eight weeks.

An intervention trial was carried out by Martin *et al.* (1990) on the effects of a single oral, high dose of vitamin A (200,000 IU) on indices of iron metabolism. The results showed a clear and significant improvement in the nutritional and health status after two months of supplementation.

Yugne and Barbara (1991) worked on safe levels of vit. A given for supplementation. Single dose of 100,000 IU given twice yearly to infants

(6-12 months) at simialr intervals had been safely used in several large scale vit. A distribution programmes. Unfortunately, toxicity can occur if daily ingestion of vit. A exceeds the limits of 2500 IU/kg of body weight or 750 IU/kg body weight in infants, 4-6 months old.

The W.H.O. and U.N. children's fund recommends that a high potency preparation of 100,000 and 200,000 IU of vit. A may be administered to measles cases in children below and above one year, respectively. They stated that this therapeutic regimen should be followed in communities with measles and fatality rates of one per cent or higher in communities with recognised vit. A deficiency (Gout *et al* ., 1992).

Similar beneficial effects of vit. A supplementation (200,000 IU) in preventing blindness among children has been reported by Darton *et al* ., (1991) and Ignatius *et al* ., (1992).

UNICEF developed a pump disperser to administer high potency vit. A solution by pump squirts. One full push of the pump squirts provides 100,000 IU of vit. A the recommended preventive dose for chidlren 6 to 11 months old and two pushes of 200,000 IU for children 12 months and older (Vitamin A, Report, 1992).

Johns *et al* ., (1992) suggested a small or large priming dose to support the use of repeated spaced doses of vit. A for treating xerophthalmia and concluded in his study that 60,000 Retinol equivalents prophylactic dose currently recommended by the WHO need not be increased.

The Indian National Programme to control vit. A deficiency by administration of a mega dose of 200,000 IU of synthetic vit. A for children

between eighteen months to two years was started in 1970. The supplementation was given to twenty five million beneficiaries under the ICDS Project (Vital News, 1993).

Vit. A supplementation of 200,000 IU to preschool children in 8 countries resulted in an average reduction in mortality rate by 23 per cent. But in Sudanese and Hyderabadi children the 200,000 IU at 6 months interval for children was inadequate to evoke a beneficial response. It was indicated that vit. A status appears to affect the child's ability to respond appropriately and adequately once infection had developed and hence appears to have impact on the source of morbidity (Beaton *et al.*, 1993).

A study conducted by Manorama *et al.* (1997) showed that the efficacy of RPO supplementation was comparable with massive dose of vit. A. RPO was found to be equally efficient in maintaining serum vit. A level. Even morbidity was comparatively less than the control group.

2.3 Promising Sources of β-Carotene

A comprehensive research finding revealed that the best source of β-carotene among edible foods could be obtained from the plant kingdom.

Dunaliella salina, a green algae found in high salt concentration and in natural water was found to be a natural source of β-carotene .This algae contains substantial concentration of inter cellular β-carotene unlike other types of algae. Blakeslea trispora, a fungi was also reported to be a rich source of β-carotene .(Vitamin A Compendium, 1976). The β-carotene contents (mg/kg) of fresh cassava, ceylon spinach, papaya, colocasia, water leaf were reported by Renquist *et al.*(1978).

Appreciable work has been done on carrots by scientists all over the world. It was estimated to contain 270 ppm of carotene.

Janabi and Nandini (1983) found that amaranth contained 1200 μg of β-carotene /40 g and could be used as supplementary food.

Crude palm oil owes its distinctive orange-red colour to its relatively high content of carotenoids among all the vegetable oils. Raw palm oil contains the highest known concentration of 500-700 ppm of agro derived carotenoids (Armughan *et al*., 1989) and thus it can be an ideal vehicle for vit.A prophylaxis.

Annapurna and Bamji (1991) reported that spirulina, another blue-green algae, possessed 300 mg per cent of β-carotene which can be a good source of vit. A for the needy population.

Crude (unprocessed) and red or golden (specially refined) palm oils are the richest natural sources of carotenoids. β-carotene , a major carotene in crude palm oil is a potent antioxidant and precursor of vit. A (Krinsky, 1993).

In a survey conducted by Devadas *et al.* (1998) reproted a wide variety of carotene containing foods have been identified. Of particular interest in the finding that in all regions 60 per cent or more these were green leafy vegetables (GLVs) while the others were roots, tubers and fruits. The β-carotene content of these foods indicates that about 30 per cent of these were rich in β-carotene with more than 5,000 γ/100 g while 20 per cent of these were modest source with 1000-5000 γ/100 g. Some of them are Kangero leaves, Gogu, Konda karivepaku, Agathi, Amaranthus tender, Ambat

chuka, Colocasia leaves, Drumstick leaves, Corriander, Mint leaves, Fenugreek leaves, Mayalu, Lettuce, Ponnaganti, Radish,Spinach leaves, Carrots, etc. Among tubers yellow sweet potato and chillies, pumpkin vegetables. Among fruits guava (country), jack fruit, mango, orange, papaya (ripe), phalsa and riped tomato are some of the rich sources of β-carotene.

2.4 Crude Palm Oil - Its Composition and Quality

The present focus is on red palm oil (RPO) as a source of vit.A which is being exploited for its natural antioxidants and high amounts of carotenoids (550 μg/g) and β-carotene (375 mg/100g) (Manorama and Rukmini 1991a).

RPO or crude palm oil is extracted from the mesocarp of the fruit of the oil palm (*Elaeis guineensis*) which comprises 90 per cent of the oil yield. RPO is a highly viscous semi solid fat and is orange-red in colour (Lovibond unit of 28R+10%). The Iodine value (IV) and slip melting point of RPO ranges from 45-56 and 31-38°C, respectively (Deffense, 1985).

RPO is a complex mixture of over 99 per cent glycerides and about 0.5 per cent non-glyceride materials. The oil may also contain around 0.22 per cent moisture and impurities such as iron (4 ppm) and copper (0.5ppm) (Armugan *et al.*, 1989). These impurities are acquired by the oil during processing and they vary with the method of processing (traditional/ industrial) followed for oil extraction (Cornelivs, 1977 and Aletor *et al.* 1990).

The non-glyceride materials (0.5%) also called unsaponifiable matter, include carotenoids, tocopherols, phospholipids (0.2-5 ppm as P)

sterols (0.03%) such as β-sitosterols, stigma sterol, compesterol, cholesterol (0.001%) squalene (200-500 ppm), methyl sterols (40-80 ppm) and dimethyl sterols (40-80ppm), sesquiterpene and diterpene hydro carbons (30 ppm), aliphatic hydro carbons (50 ppm) aliphatic alcohols (160 ppm), methyl esters (50 ppm), ketones (trace), and waxes (Trace) (Itoh *et al.*, 1973; Jacobsberg, 1974; Goh *et al.*, 1985). The Bureau of Indian Standards has set a maximum limit of 1.2 per cent for unsaponifiable matter of RPO.

The quality of RPO is judged mainly by its free fatty acids (FFA) content. Though the other parameters such as peroxide value (PV), anisidine value (AV), diene and triene values, iron and copper contents etc. also reflect the soundness of oil, they are the consequence of initial FFA content. The palm fruit contains extremely active lipolytic enzyme (lipase) which releases FFA very rapidly under favourable conditions (Abigor *et al.*, 1985).

If the fruit is bruised, the FFA in the damaged part of the fruit increases to 60 per cent within an hour (Jacobsberg, 1969).

The RPO extracted by traditional African method was reported to contain as high as 50 per cent FFA whereas Malaysian crude palm oil contained only 2-5% FFA (Cornelivs, 1977). The Regional Research Laboratories (RRL), Trivendrum has reported an extremely lower value (0.9%) of FFA for the RPO processed from the fruit bunches harvested from Central Plantation Crops Research Institute (CPCRI) at Palode, Trivendrum. Thus, the FFA content may vary for the oils produced from various regions.

Ukhun (1986) and Aletor *et al.* (1990) showed that the variation in FFA is due to differences in processing methods followed for oil extraction. The traditionally processed oils contained more FFA when compared to the industrially processed oils.

Manorama *et al.* (1989) have reported that preliminary nutritional and toxicological evaluation of crude palm oil has been computed and it was found to be nutritionally adequate and toxicologically safe for human consumption.

Upon storage at room temperature, the oil starts to separate into two phases, a lower solid phase (Stearin) and upper liquid phase (Olein). Hence, to obtain a uniform consistency of the oil and proper blending of all components, the oil has to be melted before use (Nkpa *et al.*, 1989).

Kumar (1999) has reported that RPO is safe for human consumption. FFA, PV and FA values are in acceptable range in fresh oil and the developed products were stored for 30 days.

2.5 Fatty Acid Composition of Red Palm Oil

RPO contains equal amounts of saturated and unsaturated fatty acids. The major fatty acids of RPO are palmitic and oleic acids whereas linoleic and stearic acids are present in moderate amounts. Lauric, myristic, palmitoleic, linolenic and arachidic acids may also be present but in very minor quantities. The SFA portion is made up of 44 per cent palmitic and 5 per cent stearic acid. The MUFA oleic acid accounts for 40 per cent of its composition and 10 per cent is made up of the PUFA linoleic acid.

The fatty acid composition of RPO as analysed at Malaysian Agricultural Research and Development Institute (MARDI). Palm Oil Research Institute of Malaysia (PORIM), RRL, Trivandrum and National Institute of Nutrition (NIN), Hyderabad are presented in Table 2.2.

Table 2.2. Fatty acid composition (%) of RPO from different sources

Fatty Acid	MARDI[1]	PORIN[2]	RRL[3]	NIN
Lauric : C12:0	0.1	0.2	-	-
Myristic : C14:0	1.0	1.1	1.2	0.8
Palmitic : C16:0	43.7	44.0	42.44	42.0
Palmitoleic : C16:1	0.1	0.1	-	-
Stearic : C18:0	4.4	4.5	5.17	5.1
Oleic : C18:1	39.9	39.2	37.01	42.1
Linoleic : C18:2	10.3	10.1	11.71	10.0
Linolenic : C18:3	-	0.4	-	-
Arachidic : C20 :0	0.3	0.4	-	-
Iodine value (Wijs)	52.9	53.3	52.0	47.13
Slip Melting Point (°C)	34.2	36.0	36.0	37.0

Source : 1&2. Tan and Ohe, 1981; 3. Armugan *et al.*, 1989; 4. Manorama, 1994

The uniqueness of RPO from other vegetable oils lies in its fatty acid composition and their position in the triglyceride structure. Inspite of its higher palmitic acid content, RPO does not behave like animal fats that are rich in SFA. This is because, in RPO the middle (2nd) position of triglyceride structure is occupied mainly by unsaturated fatty acid (oleic) which are absorbed into the intestine after the fatty acids at 1 and 3 positions are split off during digestion. Thus, more of oleic acid is available to the body from RPO. It was demonstrated by Mattson and Grundy (1985) that

oleic acid is active as PUFA in reducing blood cholesterol. So, the absorption of high oleic acid from RPO may be playing a relevant role in reducing cardio vascular risk (Hayes *et al.*, 1988; Ng *et al.*, 1991; Sugano and Imaizumi, 1991). RPO has desirable influences on thrombotic tendency, blood-platelet aggregation, eicosanoid biosynthesis and inhibition of tumor progression owing to its fatty acid composition (Hornstra, 1988; Rand *et al.*, 1988).

In palm oil fatty acids such as lauric, myristic, palmitic and stearic of the highest quality are present. They are used in cosmetics which take advantage of their good ability to lather, condition and provide lusture and shine. Fatty esters are produced by the esterification of fatty acids.

Single, double and triple pressed fatty acids from palm oil are comparable in quality to those produced from tallow are now commonly available.

Table 2.3 Fatty acids composition in palm olein

SFA	MUFA	PUFA	
		N-6	N-3
40%	48%	11%	1%

Palm olein contains a mixture of poly unsaturated, monounsaturated and saturated fatty acids. The relative concentrations are 44 per cent oleic acid, 10% linoleic acid, 40% palmitic acid and 5% stearic acid. The concentrations of palmitic and oleic acids are reversed in unfractionated palm oil i.e. 44 and 40 per cent, respectively. The fatty acid composition of palm oil is similar to that of the adipose tissue in most people on an ordinary diet.

The American Heart Association has recommended a ratio of 1:1:1 - SFA : MUFA : PUFA containing oils in diets as ideal combination (National Academy of Science, 1989). In the Indian context, 40 per cent SFA, 28 per cent oleic acid and 32 per cent PUFA have been recommended .

Table 2.4 Fatty acids composition in oils (%)

Fatty Acid	SFA	MUFA	PUFA	
			N-6	N-3
Groundnut	18	49	33	-
Soyabean	15	24	54	7
Safflower	10	13	77	-
Sunflower	11	20	69	-
Sesame	13	46	41	-
Rapseed (cannola)	6	62	22	10
Olive	14	77	8	1
Palmolein	40	48	11	1
Flax	9	18	16	57
Cotton seed	26	22	52	
Coconut oil	92	6	2	
Vegetable ghee (HVO)	76	19	3	2
Deshi Ghee	72	23	3	2

Source : Rohit Gandhi (1996)

Table 2.5 Fatty acids composition (%)

	Palm oil	Palm olein	Palm kernel oil
Source			
C8:0	-	-	4.4
C10:0	-	-	3.7
C12:0	0.2	0.2	48.3
C14:0	1.0	1.0	15.6
C16:0	44.0	38.0	7.8
C18:0	4.5	4.0	2.0
Unsaturated			
C18:1	39.2	44.0	15.1
C18:2	10.1	11.5	2.7
C18:3	0.4	0.4	-

Source : Malaysian palm oil information bulletin 2000

Table 2.6 Comosition of palm oil products

	Palm oil (mean)	Standard palm olein (mean)	Special palm olein (mean)	Palm stearin typical	Palm stearin range
C14:0	1.1	1.0	1.1	1.3	1.1-1.9
C16:0	44.0	39.8	31.5	54.0	47.2-73.8
C18:0	4.5	4.4	3.2	4.7	4.4-5.6
C18:1	39.2	42.5	49.2	32.3	15.6-37.0
C18:2	10.1	11.2	13.7	7.0	3.2-9.8
C18:3	0.4	0.4	0.3	0.1	0.1-0.6

Source : Malaysian palm oil promotion council, 1996

Table 2.7 Fatty acid composition of some oils/fats

	Weight percentage							
Fatty acids	Palm oil	Palm stearin	Tallow	Palm kernel oil	Palm kernel olein	Coconut Oil	Palm olein	Soya bean oil
C6	-	-	-	0.3	0.4	0.2	-	-
C8	-	-	-	4.4	5.4	8.0	-	-
C10	-	-	-	3.7	3.9	7.0	-	-
C12	0.2	0.3	-	48.3	41.5	48.2	0.2	-
C14	1.1	1.3	2.5	15.6	11.8	18.0	1.0	-
C16	44.0	55.0	26.6	7.8	8.4	8.5	39.8	6.5
C18	4.5	5.1	21.8	2.0	2.4	2.3	4.4	4.2
C18:1	39.2	29.5	42.8	15.1	22.8	5.7	42.5	28.0
C18:2	10.1	7.4	2.3	2.7	3.3	2.1	11.2	52.6
Other	0.8	0.7	4.0	0.1	0.1	-	0.9	8.0

Source : Malaysian information series, 2000

2.6 Carotenoids in Crude Palm Oil

Carotenoids are sometimes present in traces in many vegetable oils but are unusually high in RPO. The carotenoid content of RPO from Malaysia and zaire was found to vary between 500 and 700 ppm (Clegg, 1973). Larger amounts (800-1600 ppm) have been reported from Nigeria, Togo, Ivory coast and Dahomey.

A typical analysis of the compositin of carotenoids shows that α and β carotenes are the major components and the rest are γ-carotene, lycopene and xanthophylls and β-carotene constitute 85-90 per cent of the total carotenoids. Both these compounds possess pro vitamin A activity thus rendering RPO as a rich source of vit. A.

Table 4. Composition of palm oil carotenoids

% of total carotenoids	Zaire	Dahomey	Togo	Malaysia
α-carotene	32.2	85	87	29
β-carotene	54.4			62
γ-carotene	3.3			4
Lycopene	3.8	15	13	3
Xanthophyll	2.2			2

Source: Clegg (1973)

Carotenoids contribute to the deep red colour of RPO. In RPO, the carotenoid content varies with the degree of ripenese and genotype of the fruit from which it is extracted and also with nativity. RPO may contain 500-1600 ppm of carotenoids based on its origin. They also reported α and β carotene values as 36 per cent and 54 per cent respectively of the total carotenoids in RPO and the remaining 10 per cent consisted of γ-carotene, lycopene and xanthophylls (Jacobsberg, 1974; Maclellan, 1983;

Manorma and Rukmini, 1992a, Goh *et al.*, 1985; Wong *et al.* 1988). Manorama and Rukmini (1992a) reported that the β-carotene content of RPO produced in India was 70 per cent (370 μg/g) of total carotenes (540 μg/g).

RPO has the highest vit. A derived activity (500 IU vit. A/g) primarily due to its β-carotene content (Gafoorunisa, 1995). α-carotene may also contribute to the vit. A activity to some extent. The bio-availability of β-carotene from RPO was found to be on par with synthetic vit. A as per the studies of Manorma and Rukmini (1992a) on school children. Apart from their vit. A activity, palm oil carotenoids were found to be protective against membrane peroxidation and free radical formation thus inhibiting tumor progression (Sundaram, 1989). According to Young (1987) palm oil has highest concentration of carotenoids, the precursors of vit. A which imparts the characteristic red colour to it. The major components of palm oil carotenoids included 62 per cent β-carotene, 29 per cent α-carotene, 4 per cent Ψ–carotene, 3 per cent xanthophillus and 2 per cent lycopene.

According to Malaysian palm oil information bulletin the carotenoids in palm oil are mainly β-carotene (55%) α-carotene (35%) with smaller percentage of lycopene, phytoene and zeacarotenes.

These natural palm carotenoids have antioxidant and anticancer properties as demonstrated in several animal models. The most interesting property, however, is their pro-vit.A activity. Recognising this natural advantage the industry has developed a new product red palm oil that preserves the carotenoids. This product has already gained much prominence

as a natural dietary therapy in overcoming vit. A indirect blindness that is a source of millions of children around the world.

Crude palm oil is natural's richest source of the caratenoids with concentrations in order of 700-1000 ppm. This is about 15 times more than that present in carrots for example. β–carotene, a major carotene in crude palm oil is a potent antioxidant and precursor of vit. A.

Choo (1994) has also stated that crude palm oil is the richest natural plant source of carotenoids in terms of retinol (Provitamin A) equivalent. This study reports carotenoids found in palm oil, its fractions, by products and derivatives from the *Elaeis guineensis* and *E. oleifera* palms, including their hybrids and a backcross as well as the carotenoids of pressed palm fibres, second pressed oil, palm leaves, and palm derived alkyl esters, 2 novel procedure for preparing highly concentrated sources of carotenoids (>80,000 mg/kg).

Choo *et al.* (1996) has reported that recovered fibre from pressed palm fruits which is normally burned as fuel to provide energy for palm oil mills, is reputed to be a rich source of carotenoids (4000-6000 mg/kg). The major identified carotenoids were α-carotene (19.5%) β-carotene (31.0%) lycopene (14.1%) and phytoene (11.9%) (Malaysian palm oil information bulletin, 2000).

2.7 Tocopherols in Red Palm Oil

Edible oils contain varying amounts of tocopherols or vit.E which are natural antioxidants providing protection against oxidative deterioration. They are physiologically important as vit.E and technologically active as

anti-oxidants. The normal range present in RPO is 600 to 1000 ppm and this level is generally reduced in the refining process to about 50-80 per cent of that found in the crude oil (Tan and Ohe 1981). Palm oil contains both tocopherols (T) as well as tocotrienols (T_3) which are the unsaturated analogues of tocopherols. Maclellan (1983) reported the total tocopherol content of RPO as 800 ppm consisting of a mixture of 20 per cent α-tocopherol, 25 per cent α-tocotrienol, 45 per cent γ-tocotrienol and 10 per cent δ-tocotrienol. The tocopherols contribute to the stability of the oil. The RPO tocotrienols bring about cholesterol lowering effects both in animals and in humans (Qureshi *et al.*, 1991a and 1991b; Daniel *et al.*, 1991). They have a protective effect on platelet aggregation (Hornstra, 1988) and tumor progression (Sundaram, 1989), thus suggesting medical implications.

Palm oil and palm oil products are naturally occuring sources of the antioxidant vit.E constituents, tocopherols and tocotrienols. These natural antioxidants act as scavengers of damaging oxygen free radicals and are hypothesized to play a protective role in cellular aging, atherosclerosis and cancer (Walton and Packer, 1980; Hirai *et al.*, 1982; Cross, 1987; Elson and Qureshi, 1995).

Ima *et al.* (1995) had conducted a study on serum lipids of castrated rats given hormonal replacement when fed with the diets of added soyabean oil and red palm oil.

Recovered oil from palm pressed fiber is rich in vit. E (tocopherol and tocotrienols) and sterols. Residual oil (5-6% on dry basis) extracted

from palm press fibres contained vit.E (2400-3500 mg/kg) and sterols (4500-8500 mg/kg). The major identified vit.E are α-tocopherol constituted about 61 per cent of the total vit. E present. The rest being tocoteienols (alpha, gamma and delta). The major sterols present were beta-sterol (47%) campesterol (24%) and stigmosterol (15%). The oil extracted from palm-pressed fibre contained about 30% of palm kernel oil (Choo *et al.*, 1996; Malaysian Palm Oil Information Bulletin, 2000).

2.8 Stability of Crude Palm Oil upon Processing and Heating

RPO like any other oil, is subjected to refining process to remove undesirable materials such as colour pigments, oxidative components, gums, metal contaminants and volatile compounds. During this refining process, nearly all carotenes and considerable amounts of tocopherols were found to be lost (Armugan *et al.*, 1989). Goh *et al.* (1985) observed 15-57 per cent of loss of tocopherol during steam deodorization and distillation of free fatty acids in case of RPO.

Heating also brings about some changes in the organoleptic, physical and chemical properties of RPO due to oxidation of its constituents. Okiy and Oke (1986) have observed certain chemical changes in RPO heated for two hours at 100°C/150°C/200°C alternated with cooling. The findings suggested that the chemical parameters like FFA and IV were not altered due to repeated heating but the levels of PV, Anisidine value (AV) and thiobarbituric acid value increased significantly. This change was attributed to the destruction of carotenes and linoleic acid. In agreement with the above study, Manorama and Rukmini (1992b) have also showed a

decrease in carotene content on heating. They reported that repeated heating of RPO resulted in a steep fall of carotene content with each consecutive frying. The loss of β-carotene during deep frying was attributed to two factors namely (a) loss due to the incorporation into the foodstuff being fried and (b) Loss due to heat deterioration. It was also reported that the total carotene retention ranged from 69-86 per cent and β-carotene retention 70-88 per cent (Manorama and Rukmini, 1991a) in the food items incorporated with RPO and subjected to different cooking processes.

Teah (1998) reported that palm olein, with its inherent excellent frying properties, improves the frying quality of other vegetable oils when blended with them. Thus the induction period of a variety of oils was raised by blending indicating improved resistance to oxidation. The improvement is also seen in measurements reflecting primary and secondary oxidation and the formation of free fatty acids, other volatiles and polymers and also the cloud points of most vegetable oils are raised slightly (into the range - 10°C + 5°C) by blending with palm olein.

Gonalez *et al.* (1998) had conducted a study on short term *in vivo* digestibility of triglyceride polymeres, dimers and monomeres of thermooxidized palm olein used in deep frying. For this, palm olein used to fry potatoes 40 and 90 times were tested. The true digestability coefficient of palm olein used in frying 90 times was 30 per cent lower than that of unused palm olein. True digestability of triglyceride polymers and dimers of unused palm olein was > 50 per cent. After 90 uses, the digestability of dimers was significantly lower ($P<0.01$). Non-oxidized triglyceride

hydrolysis was negatively affected by the presence of large amounts of thermoxidised compounds. The amount of monoglycerides and free fatty acids found in initial fat also decreased as a consequence of the arrest of pancreatic lipase activity by thermoxodized compounds formed through repeated frying.

2.9 Acceptability of crude palm oil in food preparation

RPO has widespread acceptability as cooking oil in many parts of Africa. It is a major source of dietary fat in Nigeria being used extensively in the preparation of stews, soups, in cooking, frying and in the preparation of African salad. The widespread acceptability of RPO is due to its high solid glyceride content which gives it the desirable consitency without hydrogenation. Moreover, it is readily digested, absorbed and utilized because of the occurrence of oleic acid in the second position of triglyceride structure.

The acceptability of RPO in certain Indian foods has been tested by some investigators. Parvathi and Sailaja.(1988) reported better acceptability of RPO for shallow fat frying and seasoning than for deep fat frying and the cooked foods were reported to have better storage stability.

Palm oil has been reported to be safe and nutritious source of edible oil for healthy humans for thousands of years (Cotlrell, 1991).

According to Calloway and Kurtz (1956) like other common edible fats and oils, palm oil is easily digested, absorbed and utilized in normal metabolic process. It plays a useful role in meeting energy and essential fatty acid needs in many regions of the world. Chemical, biochemical and

toxicological studies indicated that RPO is safe for human use (Manorama and Rukmini, 1991b; Manorama *et al.*, 1989, Manorama *et al.*, 1993).

Manorama and Rukmini (1991b) has conducted a study on weanling albino rate of the wistar/NIN for 28 and 90d. Diets contained 10% of either CPO, groundnut oil (GNO) or refined palm olein oil (RPO) and adequate amounts of all other nutrients. No adverse effects were observed as judged by growth rate, feed, efficiency ratio, protein efficiency ratio, net protein utilization, digestability, fat absorption, nitrogen balance, phosphorus and calcium retention, serum enzymes and blood heamatology which were comparable with control values. Lipid profiles of the animals of the 28d study indicated that CPO and RPO had higher amounts of cholesterol and triglycerides than did GNOalthough tissue lipids were comparable. In the 90d study lipid concentrations were comparable with control values. The results suggest, that CPO has adequate nutritional quality compared with GNO and RPO palm oil is also used in the preparation of the products like shortenings, vanaspati, margarines, ice creams, cookies, crackers, cake mixes, icing, instant noodles, non-dairy creamer, biscuits and doughnuts (Malaysian Palm Oil Promotion Council ,1996).

Sundaram *et al.* (1990) had developed crude palm oil based products and compared with the control of each product type. The control and palm oil based frying fats and packet margarins were similar in texture and quality characteristics whereas the control margarine had a higher polyunsaturated content and was more readily spreadable than the palm oil product. Fatty acid compositional differences were evident based on the composition of

the individual oils used in these formulations. Bakery products made from both control and palm oil bakery margarines were also similar in their eating qualities. Control snack food consistantly had a higher polyunsaturated and Saturated ratio than had palm oil products. However difference in texture, taste or fat content were not apparent between the product types. Replacing dairy fat with palm oil posed problems requiring stringent quality control of the raw materials. Palm oil cheese was less acceptable than the dairy cheese. Differences in taste between the dairy and palm oil substituted dairy products is attributed to a lack of quick melting short chain fatty acids inthe latter. In spite of these differences, product acceptability among volunteers was excellent.

Manorama and Rukmini (1992b) conducted acceptability studies with recipes made using RPO. RPO was found to be well accepted in preparations where its yellow/orange colour blended well with the natural colour of certain Indian food items like 'upma', 'tamarind rice', deep fried products and cake.

Studies recently conducted at Avinasalingam College of Home Science, Coimbatore by Devadas *et al.* (1998) reported that the products like 'Vegetable rice', upma, sambar, cakes, biscuits and cookies were accepted when 100 per cent RPO was used during cooking.

2.10 Storage stability of crude palm oil based products

Storage of oils bring about certain changes in the physico-chemical constituents of the oils, depending upon the type of oil and the storage conditions like time, temperature and the container in which the oil is being

stored (Pandey, 1980; Huang *et al.*, 1987; Nasirullah *et al.*, 1982; Murthi *et al.*, 1987).

Not many studies have been conducted on the storage stability of RPO. A study by Ukhun (1986) showed that on storage, the IV of RPO increased with increase in water activity. A water activity of 0.94 at 50°C or 0.19 per cent moisture was found to be the ideal condition for storage of RPO as per the studies of Chong and Ong (1987).

2.11 Studies on supplementation trials with crude plam oil

A study was carried out on bioavailability of β-carotene in RPO in school children aged seven to nine years with marginal vit. A deficiency through supplementary feeding of RPO snacks. Twenty four children belonging to low socio-economic group and studying in government aided schools were selected and were assigned to two experimental groups. The first group belonged to RPO group and the other to vitamin A group. The modified relative dose response test was performed at the beginning of the experiment to assess their vit. A status (Rukmini, 1994, Manorama *et al.*, 1996).

The first group of children were supplemented with RDA of β-carotene (2400 μg) through 'suji halwa' made in RPO, daily for two months, 8 g of RPO was added per piece of suji halwa supplied to each child and similarly, the second group was supplemented with RDA of vit. A (600 μg) in the form of synthetic vit.A palmitate drops added orally, followed by a piece of suji halwa' made with GNO. After two months of supplementation, the MRDR test was repeated to assess the magnitude of improvement in the status.

The results of the study showed an increase in serum vit. A levels from 0.86±0.14 to 1.89±0.023 μmol/lit in RPO group and 0.74±0.12 to 1.94± 0.24 μmol/lit in control group who were fed with 600 μg of vit. A orally. Thus, it was concluded that supplementary foods made with RPO had a significant impact on vit. A status of children.

A study conducted by Manorama *et al.* (1997) showed that the efficacy of RPO supplementation was comparable with massive dose of vit. A. RPO was found to be equally efficient in maintaining serum vit. A level. Even morbidity was comparatively less than the control group.

When the efficacy of periodic (monthly) dose of vit. A and RPO was compared. RPO was found to be more efficient than vit. A. The final serum vit. A levels had increased and morbidity was also found to be lower in the group that received RPO in comparison with those who received periodic vit. A supplements. Palm oil based products were especially developed by Sundram *et al.* (1990) for a nutritional trial evaluating some aspects of cardiovascular risk profile in man. Products included oils and fats, bakery products, snack foods and substituted dairy products and reported that palm oil has the effect of decreasing total blood cholesterol and bad LDL-cholesterol.

Henry *et al.* (1997) studied the influence of dietary palm oil fractions on protein utilisation in the growing rat. At 30 days of age, 4-6 groups of 4 sprague-Dawley rats were fed on 1 of 6 semi purified diets that differed only in the palm oil fraction. Diets contained casein 200 g/kg carbohydrate 550 g/kg and fat 200 g/kg. The different palm oil fractions were crude palm

oil (CPO), refined palm - kernel oil (PKO), refined palm oil (RPO), refined palm stearin (RPS) and refined palm oil (RPOL). The control groups were given olive oil (OO) as the dietary fat source.The conversion efficiency of dietary protein was assessed as net protein utilisation (NPU) using a 10 day comparative carcase technique. Body weight gain and food intake were not altered by the various palm-oil fractions. However, the NPU of rats fed on the RPO diet was higher ($P<0.05$) than that of rats fed on all other palm oil fractions and the olive oil control. It was concluded that RPO has the potential to significantly improve NPU in the rat, compared to 4 other palm oil fractions as well as olive oil.

Ng. *et al.* (1988) had conducted a study on male rats 21 to 25 days old were given a fat-free diet or diets with 10 or 20 per cent soybean oil, refined, bleached and deodorized palm oil, palm olein or plasma stearin for 6 weeks. Refined palm oil and its fractionation products were easily digested, well absorbed and efficiently utilized for growth. Digestibility for palm oil, palm olein, palm stearin and soybean oil was 95.8, 96.4, 94.2 and 98.8, respectively. The relative rates of absorption for the refined palm oil fractions after 3 or 6h and their AT50 (time after which 50% of the oil had disappeared from the gastro intestinal tract) where in the order, palm olein > palm oil > palm stearin,

Pust *et al.* (1985) has conducted two mass interventions in the local low-energy density diet and were evaluated for safety, acceptability and nutritional efficiency in a four group matched study of 896 papua new Guinea children 12 to 54 months old. A single dose of 125 mg pyrantel

pameate and an 800 mg supply of red palm oil were given monthly at the regular child head clinics. Both were safe and highly accepted.

Adelekan *et al.* (1997) has conducted a study on 204 preschool children of South West Nigeria. Vit. A status of the chidlren was assessed from the concentration of retinol in their plasma. These children were fed with carotene rich red palm oil products for 6 or more times per week and serum retinol levels were found to be significantly increased than that of before feeding level.

Ghafoorunissa (1995) has studied the effects of the substitution of red palm oil with groundnut oil in subjects from the middle income group No rise in serum cholesterol and aggregability of platelets was observed indicating that palm oil may not produce the deleterious effects associated with saturated fatty acids.

A pilot study was conducted by school of community health. western Australia and found that the energy intake of chidlren 1-4 years old from village in the high lands regions of pupua New Guinea increased by 15 per cent using a supplement of palm oil. This resulted in a significantly greater (1.66 kg) weight gain, during a period of 9 months, compared with the control group (1.2 kg). Palm oil had non-significant effect on serum albumin and haematocrit.

Guptill *et al.* (1993) developed a weaning food based on red palm oil along with toasted cowpea flour adding sugar which increased energy and protein density of the traditional maize or sorghum starch porridge used for weaning from 38 to 85 KCal and protein 0.8 to 2.0/100g. 57 per cent of

the respondents knew the modified recipe, 48 per cent tried it and 17 per cent adopted it with the intention of using it in future.

Babji *et al.* (1998) also used partially hydrogenated palm oil inspite of animal fat in beef burgus and was widely accepted by the people.

Jaswir *et al.* (1998) has conducted a 2 stage optimization of ingredients in durian leather formulation by using response surface methodology. In stage 1 the independent variables were glucose syrup solids (GSS) and sucrose and in stage 2 the variables were hydrogenated palm oil and soy lecithin. Based on the responses to sensory acceptability attributes including taste, aroma, texture, appearance and overall acceptability, the most acceptable formulation was a combination of 10% GSS, 5% sucrose, 2.67% hydrogenated palm oil and 0.452% soy lecithin. Chemical analysis also showed that during processing nutrient composition was relatively unchanged.

Tomarelli (1991) had developed a vegetable oil composition with a randomized palmitic acid oil as the sole palmatic acid oil are described. These all vegetable oils consumption is intended for use in human infant nutritional products and combine a lauric acid oil, an oleic acid oil and linoleic acid oil with randomized palmatic acid oil. Sunflower oleic acid oil and canola oil may also be used as oleic acid oils. For premature and low birth wt. infants, medium chain triglycerides are also included in these compositions.

2.12 Other nutritional benefits of palm oil

Palm oil contains much less saturated fat than palm kernel oil or coconut oil. Palm oil has been used in food preparation. It is consumed

world wide as a cooking oil, in margarines and shortening and as an ingredient in fat blends and a vast array of food products. Food manufacturers choose palm oil because it has a distinctive quality, requires little or no hydrogeneration and lengthens the shelf life of products.

(a) Palm oil and coronary heart disease

A number of pre-1990 human feeding studies reported that palm oil diets showed a reduction of blood cholesterol values ranging from 7 to 38 per cent (Ahrens *et al.*, 1957; Anderson *et al.*, 1976; Baudet *et al.*, 1984; Mattson and Grundy, 1985; Bonanome and Grundy, 1988).

A comparative study in young Australian adults showed that the total blood cholesterol, triglycerides and HDL cholesterol levels of those fed on palm oil (Palm olein and olive oil were lower than those fed on the usual Australian diet (Choudhary *et al* ., 1995). They showed that young Australian adults fed on palm oil diets had the same total blood cholesterol, triglycerioles and good HDL-cholesterol levels as those fed on olive oil.

A double blind cross over study (Sundaram *et al* ., 1997) showed that palm olein rich diet is identical to oleic acid rich diet. Transfatty acid rich diet performed the worst by elevated total cholesterol, bad, LDL-cholesterol, lipoprotein and depressed 'good' HDL-cholesterol relative to oleic acid, stearic acid, lauric and myristic acids rich diets.

A study on fifty one Pakistani adults showed that those given palm oil rich diet performed better than sunflower oil. Palm oil increased HDL-cholesterol and APO A-1 levels. Hydrogenated cotton seed oil behaved the worst by raising serum triglycerides and lipoprotein levels (Farooq *et al.*, 1996).

A study by a group of researchers from the National Institute of Nutrition and Food Hygiene, Beijing, China compared the effects of palm oil, soybean oil, peanut oil and lard (Zhang *et al.*, 1997a; Zhang *et al.*, 1997b; Zhang *et al.*, 1995). They showed that palm oil has the effect of decreasing total blood cholesterol and 'bad' LDL - cholesterol and increasing the level of 'good' HDL-cholesterol. Soybean oil and peanut oil has no effect on the blood cholesterol but lard increased the cholesterol levels. Among those hydrocholesterolemic subjects, palm oil diet lower the cholesterol levels.

Study conducted on healthy Indian subjects (Ghafoorunisa *et al.*, 1995) showed that palm olein and groundnut oil have comparable effects. Both of the oil do not induce hypercholesterolemia.

Sundaram *et al.* (1995) performed a dietary intervention study on a free-living Dutch population which normally consumes diets high in fats. Using a double blind cross-over study design consisting of two periods of six weeks of feeding, the normal fat intake of a group of 40 male volunteers was replaced with 70 per cent palm oil. The palm oil diet did not raise serum total cholesterol and 'bad' LDL - cholesterol, and caused a significant increase in the 'good' HDL - cholesterol and a significant reduction in 'bad' LDL- triglycerides.

The effect of palm olein and canola oil on plasma lipids was examined in double blind experiments in healthy Australian adults. Palm oil performed better than canola oil in raising the 'good' HDL - cholesterol (Truswell *et al.* 1992).

A cross over feeding study showed that the blood cholesterol, triglycerides, HDL-cholesterol and LDL cholesterol levels of palm olein and oleic oil diets were comparable (Ng *et al.*, 1992).

A Malaysian study (Sundaram *et al.*, 1995, 1994; Ng *et al.* 1991) was conducted to compare the effects of diets containing palm oil (olein), corn oil and coconut oil on serum cholesterol. Coconut oil raised serum total cholesterol by >10 per cent whereas both corn and palm oil diets reduced the total cholesterol, corn oil diet reduced the total cholesterol by 36 per cent and palm oil diet by 19 per cent.

A similar cholesterol-lowering effect of palm oil was observed in 110 students in a study conducted in Malaysia (Marzuki *et al.*, 1991). The study compared the effect of palm oil with that of soybean oil. Volunteers fed on palm oil (olein)and soy oil for five weeks, with a six week wash out period, had comparable blood cholesterol levels. However, the blood triglycerides were increased by 28 per cent on the soybean oil diet. Thus the impact of palm oil in serum lipids is more like that of a monoun saturated rather than a saturated oil. There appear to be several explanations :

1. Palm oil is made up of 50 per cent unsaturated fats. It is not totally saturated and the saturated fatty acids present are palmitic (90%) and stearic (10%). Stearic acid does not elevate blood cholesterol and palmitic acid does not raise blood cholesterol level is in normal range (Hayes, 1993; Hayes *et al.*, 1995; Hayes *et al.*, 1991; Khosla and Hayes, 1994; Khosla and Hayes 1992; Lindsey *et al.*, 1990).

2. The vit. E particularly the tocotrienols present in palm oil can suppress the synthesis of cholesterol in the liver (Qureshi *et al.*, 1986). As a consequence, tocotrienols lower blood cholesterol levels (Qureshi *et al.*, 1995; Qureshi *et al.*, 1991a; Qureshi *et al.*, 1991b; Qureshi *et al.*, 1980; McIntosch *et al.*, 1991).

3. The position of the saturated and unsaturated fatty acid chains in a triglyceride backbone of the fat molecule determines whether the fat will elevate cholesterol level in the blood (Kritchevsky, 1996; Kritchevsky, 1995; Kritchvesky, 1988 and Innis *et al.*, 1993). In palm oil 75 per cent of the unsaturated fatty acids chains are found in position 2 of the carbon atom of the triglyceride backbone molecule (Padley *et al.*, 1986; Berger, 1983). This could explain why palm oil is not cholesterol-elevating.

Table 2.9. Fatty acids composition of palm oil

Fatty acids		Composition (%)	Effects on serum cholesterol
Lauric	C12:0	0.2*	↑or Neutral
Myristic	C14:0	1.1*	↑
Palmitic	C16:0	44.3	Neutral
Stearic	C18:0	4.6	Neutral
Oleic	C18:1	39.0	↓
Linoleic	C18:2	10.5	↓
Others		0.3	-
Palm oil		100%	↓

Palm oil contains insignificant amounts of cholesterol raising saturated fatty acid (Lauric and Myristic acids)

Source : Malaysian Palm Oil Promotion Council, Kualalumpur, Malaysia, 1996.

(b) Palm oil prevents the formation of thrombus in the blood vessels

Blood clotting can be induced by injury to the blood vessels wall and the alteration in the aggregating properties of blood platelets.

Hornstra (1988) demonstrated the palm oil has anti-clotting effect, and is as anti-thrombotic as the highly unsaturated sunflower seed oil.

Holub *et al.* (1989) reported that the vit. E in palm oil inhibits human platelets from "sticking" to each other . Other supporting evidence showed that a palm oil diet either increases the production of a hormone that prevents blood clotting (Prostacyclin) or decreases the formation of a blood-clotting hormone (thromboxane) (Sugano and Imaizumi, 1991; Sundram *et al.*, 1990; Rand *et al.*, 1988; Abeywardena *et al.*, 1989; Charnock 1989; Ng *et al.*, 1992). Thus scientific evidence indicates that the palm oil diet is as anti-thrombotic as one based on polyunsaturated oil.

(c) Palm oil does not promote the formation of plaques in the arteries

A Netherlands study was conducted on rabbits to test the effect of palm oil on atherosclerosis (Hornstra, 1988). After feeding the rabbits for 1½ years palm oil and sunflower oil diets caused the lowest degree of atherosclerosis in comparison with fish oil and olive oil.

Similarly Klurfeld *et al.* (1990) also conducted the study on rabbits and compared the effects of palm oil with hydrogenated coconut oil, cotton seed oil, hydrogenated cotton seed oil, and an American fat blend containing a mixture of butterfat, tallow, lard, shortening, salad oil, pea nut oil and corn oil. At the end of the 14 month feeding period, coconut oil fed rabbits had the most atherosclerotic leisone, while in palm oil-fed rabbits, the number of lesions was no different from that with the other oils.

Human studies reported that tocotrienols (from palm oil) supplementation can reduce restenosis of patients with carotid atherosclerosis (Kooyenga *et al.*, 1997 and Tomeo *et al.*, 1995)

(d) Palm oil and cancer

Palm oil is the richest known source of tocotrienols (Slover, 1971). No other common edible oil (except rice bran oil) contains this form of vit. E in significant amount.

Tocotrienols of palm oil exhibit anti-cancer properties (Komiyama *et al.*, 1989a; Guthrie *et al.*, 1993; Goh *et al.*, 1994; Nesaretnam *et al.*, 1992). Tocotrienols have greater physiological efficiency in inhibiting the growth of human and mouse tumour cells than tocopherols (Kato *et al.*, 1985; Komiyama *et al.*, 1989b; Sundaram *et al.* 1989; Guthrie *et al.*, 1995; Sylvester *et al.*, 1986).

Carroll (1995) and Guthrie (1997a; 1997b) showed that tocotrienols inhibit proliferation and growth of both esterogen receptor negative MDA-MB-435 and receptor positive MCF-7 human breast cells in culture. Gamma tocotrienol is 3 times more potent in stopping the growth of human breast cancer cultured-cells than tamoxifen (a drug widely used in the treatment of breast cancer). When used together with Tamoxifen, the combination was found to be 45 times as potent. In comparison, tocopherols have been found to have no effect on the growth of breast cancer cells. A study conducted by Nasarethnam *et al.* (1998) also showed similar results. Carroll (1995) concluded that evidence from animal and *in vitro* studies indicate that the tocotrienols of palm oil are effective anti-cancer agents

and that there is adequate justification for clinical trials in human cancer patients.

(e) Palm oil carotenoids

The beneficial effects of carotenes on cancer and other chronic diseases have been demonstrated in population studies and human clinical trials (Krinsky 1993; Bendich, 1990; Garewal, 1993; Ziegler *et al.*, 1993; Greenberg, 1993; Zhang *et al.*, 1992; Wolf, 1993; Greenberg *et al.*, 1990; Blot, 1993).

CHAPTER-3

MATERIALS AND METHODS

In order to improve the vitamin A status of school children belonging to the poor segment of society, different supplements, utilizing crude palm oil and other readily available food ingredients were developed using simple home scale techniques. These developed supplements were analysed for nutritional and organoleptic characteristics. Shelf life of the products were assessed by storing products for 45 days at room temperature.

These developed supplements were fed to (7-9 yrs) school children of Government Primary School, Canal Colony, Hisar for a period of one month. The impact of feeding these supplements on the nutritional status of children was studied using biochemical assessment i.e. serum retinol level.

This chapter contains relevant information pertaining to research design and other methodological steps used for present investigations distinctively described under the following heads and subheads.

3.1 Development of supplementary foods

3.1.1 Recipe selection for laboratory preparation

3.1.2 Procurement of material

3.1.3 Recipe preparation

3.2 Nutritional evaluation of crude palm oil

3.2.1 Moisture

3.2.2 Fatty acid composition.

3.2.3 β-carotene and total carotenoids

3.2.4 Non enzymatic browning

3.2.5 Peroxide value

3.2.6 Free fatty acids

3.2.7 Fat acidity

3.3. Nutritional analysis of developed products

3.3.1 Proximate analysis

3.3.2 β–carotene and total carotenoids

3.4 Acceptability and storage of developed products.

3.4.1 Acceptability of developed products

3.4.2 Storage Studies

3.4.2.1 Sensory evaluation

3.4.2.2. Nutritional evaluation of stored products

(i) β-carotene and total carotenoids

(ii) Non enzymatic browning

(iii) Peroxide value

(iv) Free fatty acids

(v) Fat acidity

3.5 Locale of research

3.6 Nutritional status assessment

3.6.1 Dietary assessment

3.6.2 Anthropometric measurements

3.6.3. Clinical assessment

3.6.4 Biochemical assessment

3.7 Selection of Supplements and subjects for feeding trials

3.8 Feeding trials and its impact on nutritional status

3.9 Statistical analysis

3.1 Development of supplementary foods

Dietary survey conducted by various workers have shown that most of the diets consumed by school children are deficient in protein energy, fat and also vitamin A . Therefore, keeping in view the necessity of supplementation, supplementary foods were developed by incorporating crude palm oil. Crude palm oil was chosen for developement of supplements because of its high β–carotene (375 µg/g) and total carotenoids (500-700 µg/g) contribution.

3.1.1 Recipe selection for laboratory preperation

Twelve recipes based on commonly available ingredients were selected for preparation in the laboratory by incorporating crude palm oil.

3.1.2 Procurement of material

All the ingredients were procured from the local market. These were cleaned for dust and other extraneous material or sieved, as required. The ingredients were stored at room temperature in plastic bags. The crude palm oil was procured from Pedavegi, West Godawari district, Andhra Pradesh.

3.1.3 Recipe preparation

The proportions of ingredients for each recipe were so worked out that half of the ghee used in the preperation was substituted by crude palm oil and the developed supplement was devided among the respondents to provide 5g of crude palm oil , so that they could provide at least 1323 µg of β-carotene per serving. Simple home scale processing methods were used in preparation of supplements so that mothers could easily follow these techniques at household level.

The following supplementary foods were developed in the lab :

1. Biscuit
2. Nankhatai
3. Nutritious Ladoo
4. Besan burfi
5. Suji ladoo
6. Upma
7. Cake
8. Doughnuts
9. Lemon rice
10. Sweet & salty biscuit
11. Poha
12. Namkeen para

Method of Preparation

Biscuit

Ingredients	:	Maida	175 g
		Sugar	100 g
		Ghee	57 g
		Crude palm oil	57 g
		Egg	1 No.
		Coconut	10 g
		Sodium bicarbonate	¼ tsp
		Baking powder	¼ tsp

Method

1. Creamed sugar, ghee and crude palm oil till light and fluffy
2. Sieved maida, Sodium bicarbonate and coconut was added
3. Beated eggs with essence and added to creamed mixture.
4. Mixed Maida and baking powder to the above mixture.
5. Formed into dough and rolled out
6. Kept in refrigerator till set
7. Divided the dough into small balls of uniform size
8. Placed on a greased tray and baked at 130^{0}C for 45 min.

Nankhatai

Ingredients	Maida	:	150 g
	Sugar	:	115 g
	Ghee	:	60 g
	Crude palm oil	:	60 g
	Curd	:	1 tsp.
	Ammonia carbonate	:	1 tsp
	Sodium bicarbonate	:	1 pinch

Method

1. Creamed ghee, sugar and crude palm oil till light and fluffy
2. Sifted the flour twice along with soda bicarbonate
3. Ammonia carbonate was dissolved in curds
4. Mixed the Maida and curd to creamed mixture and kept in refrigerator till set
5. Divided the dough into small balls of uniform size
6. Placed on greased tray and baked at 150^{0}C for 20 min.

Nutritious Ladoo

Ingredients

	Wheat flour	:	80 g
	Bengal Gram flour	:	80g
	Sugar	:	120 g
	Sesame seeds	:	40g
	Ghee	:	25 g
	Crude palm oil	:	25 g

Method

1. Sieved wheat flour and bengalgram flour separately
2. Melted ghee and wheat flour was fried for 2 min.
3. Bengal gram flour was added and fried till golden brown

4. Sesame seeds were roasted
5. Mixed all the ingreditents and removed from fire.
6. Shaped into ladoo with wet hands.

Besan burfi

Ingredients

Bengal gram flour	:	125g
Sugar	:	75 g
Ghee	:	20 g
Crude palm oil	:	20 g
Nuts	:	10g

Method

1. Fried bengalgram flour on slow flame till golden brown
2. Prepared sugar syrup of two thread consistency
3. Added sugar syrup to fried bengal gram mixture and stirred continuously
4. Cooked the mixture till it started leaving the sides of the pan.
5. Poured on a greased plate and cut into pieces of desired shape and nuts were added.

Suji ladoo

Ingreditents

Semolina	:	125g
Ghee	:	20 g
Crude palm oil	:	20g
Sugar	:	75g
Nuts	:	10g

Mehod

1. Fried semolina on low flame till golden brown

2. Added sugar and ghee and mixed well.
3. *Made into balls with the help of milk*

UPMA

Ingredients

Suji	:	100g
Crude palm oil	:	25g
Ground nuts	:	25 g
Green chillies	:	3 No
Onion	:	1 No
Ginger	:	1 piece
Mustard seeds	:	1 tsp
Curry leaves	:	*1 twig*
Water	:	200 ml
Salt	:	To taste

1. Sieved suji and roasted till golden brown
2. Heated oil and added chopped green chillies, onions, mustard seeds and curry leaves
3. Fried till onions became transparent
4. Added water and salt and allowed to boil
5. Added suji gradually with constant stirring
6. Allowed it to simmer for few minutes and removed from fire

Cake

Ingredients

Maida Refined flour	:	225 g
Ghee	:	50g
Crude palm oil	:	75 g
Sugar	:	125 g
Lemon	:	1 No.

Eggs	:	1 No.
baking power	:	½ tsp

Method

1. Pre heated the oven at 350^{0}F
2. Sifted flour alongwith backing powder twice.
3. Creamed sugar, ghee and crude palm oil till light and fluffy.
4. Beated the egg white along with lemon essence till light and fluffy.
5. Added Egg white to creamed mixture.
6. Folded flour in the above mixture.
7. Poured mixture into greased and lined tin.
8. Baked at 350^{0}F for 1 hour

Doughnuts

Ingredients

Maida	:	200 g
Sugar	:	75 g
Crude palm oil	:	25 g
Egg	:	1 No.
Baking power	:	1 pinch

Method

1. Creamed sugar and oil.
2. Beated egg and added to the above mixture.
3. Sieved maida along with baking power.
4. Added maida to creamed mixture and stiff dough was made using water.
5. Dough was rolled out and cut with cutter
6. Doughnuts were deep fried and rolled in ground sugar

Lemon rice

Ingredients

Rice	:	100g
Green chillies	:	2
Mustard seeds	:	1 tsp
Lime	:	2 No.
Bengalgram dal	:	1 tsp.
Black gram dal	:	1 tsp.
Groundnuts	:	25 g
Crude palm oil	:	15g
Curry leaves	:	few
Salt	:	to taste

Method

1. Lime Juice was extracted and kept covered
2. Oil was heated, mustard seeds, dals, nuts, chillies and curry leaves were added
3. Added these seasonings to cooked rice
4. Lime juice was sprinkled along with sufficient salt and mixed well

Sweet and Salty Biscuit

Ingredients

Maida	:	100g
Sugar	:	20 g
Ghee	:	20g
Crude palm oil	:	20g
Milk	:	40ml
Soda bicarbonate	:	A pinch
Salt	:	3.5 g

Cumin seeds	:	1.5 g
Ammonium bicarbonate	:	1 tsp

Method

1. Creamed ghee and sugar.
2. Sieved maida thoroughly with soda bicarbonate
3. Dissolved ammonium bicarbonate in milk.
4. Milk , maida and cumin seeds were added to creamed mixture.
5. Dough was rolled out into 1½cm thick.
6. Cut in the desired shape
7. Baked at 150°C for 25 min.

Poha

Ingredients

Rice flakes	:	10 g
Peanuts	:	25 g
Crude palm oil	:	20 g
Green chillies	:	3 No.
Salt	:	To taste
Chilli powder	:	½ tsp
Garam masala	:	½ tsp
Onion	:	1 no.

Method

1. Rice flakes were washed with water and water was drained.
2. Oil was heated and green chillies, chopped onions, peanuts salt, chilli powder and garam masala were added and fried until onions became transparent
3. Rice flakes were added to this seasonings and mixed well.

Namkeen para

Ingredients

Maida	:	150 g
Crude palm oil	:	30 g
Salt	:	To taste
Ajwain	:	¼ tsp
Ammonium bicarbonate	:	½ tsp
Fat	:	for frying

Method

1. Maida was sieved and crude palm oil was added.
2. Ammonia bicarbonate and salt were dissolved in water and added to Maida along with Ajwain.
3. Hard dough was made.
4. Kept the dough in mould
5. Pressed the mould and extracted the dough into desired shape.
6. Fried the extracted dough till brown colour

3.2 Nutritional evaluation of crude palm oil

3.2.1 Moisture

Moisture was determined by the method of A.O.A.C. (1990) by drying sample at 100^{0}C in hot air oven to a constant weight and calculated as follows :

Moisture (%) : $W_2/W_1 \times 100$

Where, W_1 : Weight (g) of Sample

W_2 : Loss of weight (g)

3.2.2 Fatty Acids Composition

As per the method of Metcalfe *et al.* (1966) fatty acid composition was determined..

The separation of compounds in a gas chromatography depends on the difference in the partition coefficients between the liquid and gaseous phases of the constituents in a mixture. These constituents with a high affinity for the stationary phase will tend to dwell in it. These will take longer time to travel through the column, than those with little or no affinity for the stationary phase.

Reagents used

1. Petroleum ether
2. 0.5N Sodium hydroxide: Dissolved 20g NaOH in methanol and made up to 1 litre with methanol.
3. 12% boron triflouride in methanol (commercially available)
4. Sodium chloride (Saturated)
5. Standard peanut oil simulating reference mixture (Nuchek 21A)

Gases

1. Carrier : helium, minimum purity 9.95 mol %
2. F.I.D. : a) Hydrogen, minium purity 99.95 mol %
   b) Air, dry
3. Nitrogen (Research grade)

Procedure

1. Transferred 5ml of crude palm oil into a small culture tube and evaporated the solvent under a steam of nitrogen gas.
2. 1.3 ml of 0.5 N NaOH in methanol was added and heated in a boiling water bath for 5 min.
3. Cooled and added 2ml of BF_3 in methanol
4. Heated for 5min in a boiling water bath.
5. Cooled and added 2ml saturated NaCl solutions, kept for shaking on a tube rotator for 10 min.
6. 2 ml petroleum ether was added and kept for shaking on tube rotator for 5 min and centrifuged at 4000 rpm for 5min.

7. Supernatant petroleum ether was transferred into automatic sampler vial.
8. Adjusted the carrier gas (Helium) flow to 50ml/min (Primary pressure 6kg./cm^2)
9. After ignition of the flame ionization detector, maintained the hydrogen gas flow to 0.6 kg/cm^2 and air to 0.5 kg/cm^2
10. Maintained the injection port and flame ionization detector temperatures at 260^{0}C
11. Programmed the column temperature to hold the column at 190^{0}C for 4 min. initially, followed by a step up of 10^{0}C/min to reach final temperatures of 250^{0}C and kept for 2 min.
12. Injected 1-2µl of the sample the containing methyl esters of fatty acids into the gas chromatography through the injection port.

Calculations

1. Identified the peaks by retention time or position on the recorder chart using a standard reference mixture. The fatty acid methyl esters eluted in the order-palmitic (16:0), stearic (18:0), oleic (18:1), linoleic (18:2), arachidic (20:0), eicosenoic (20:1), behenic (22:0) and lignoceric (24:0) when the above mentioned column was used.
2. Calculated percentage of each component from the ratio of each peak area (integrator count) to sum of areas (integrator count) under all peaks and reported as percentage by weight.

3.2.3 β–carotene and total carotenoids (Rao, 1967)

The individual carotenoids are separated on a column of calcium hydroxide or alumina and determined spectrophotometrically.

Reagents used

1. Potassium hydroxide

Prepared 60% KOH in water and combined with distilled alcohol in the ratio of 1:5

2. Ethanol/alcohol-Distilled
3. Calcium carbonate
4. Petroleum ether
5. Acetone 3% in petroleum ether
6. Calcium hydroxide or aluminium oxide (Active)
7. Anhydrous Sodium Sulphate.
8. Glass wool
9. Glass pieces

Procedure

Preparation of the sample : Ground two to five g of sample finely using glass pieces, mixed with 25ml of alcoholic KOH (12%) and allowed to stand over night for Saponifications or shake in a water bath for 30 min at 37°C at 6-7 speed. Added a spatula of calcium carbonate and vertex. Added 30ml petroleum ether and vertex for 5 min. Allowed the layers to separate and removed the top layer into a separating funnel. Repeated this till solvent layer is colourless. Pooled all the extracts into separating funnel. Added 50 ml water, shaked and discarded water layer. Repeated this till solvent is free of KOH. This was tested with litmus paper. Filtered the petroleum ether extract through a funnel pluged with glass wool added with anhydrous sodium sulphate, into a conical flask. Washed the anhydrous sodium sulphate with 20-50 ml of petroleum ether and combined all extracts and measured the volume and made upto 100ml volume with petroleum ether. Took 20 ml of the extract and concentrated to 5 ml. For total carotenoids measured the OD of extract at 450 nm.

Preparation of the column using aluminium oxide

Packed the column (30×1cm) with 6 cm of aluminium oxide under gentle suction. Added 1-2 cm of anhydrous sodium sulphate on top of the packed column. Wetted the column initially with petroleum ether.

Separation of carotenoid pigments

Charged five ml of the concentrated extract containing about 40-100 µg of the total carotene on the column. 3% acetone in petroleum ether was added to develop colour bands. Collected 50 ml fraction after the band drops 1cm from the bottom of the column and measured the optical density (OD) at 450 nm in spectrophotometer.

Calculations

One OD is equivalent to 4 µg/ml of β-carotene when measured in 1cm cell

$$\beta\text{–carotene (µg/g)} : \frac{50\times \text{O.D.}\times 4\ \mu g\times 100}{20\times 2}$$

50 = Total volume of β-carotene eluted from column

OD = Optical density of elute

4 µg = 1 OD is equivalent to 4 µg/ml

100 = Volume made

20 = Amt. passed through column.

2 = wt. of sample.

For total carotenoids

$$\text{Total carotenoids(µg/g)} = \frac{100\times \text{O.D.}\times 4\ \mu g}{2}$$

3.2.4 Non-enzymatic browning

The increase in absorbance of a sample at 440 nm was taken as

measure of non-enzymatic browning as described by Ranganna (1977).

Moisture free sample of one gram was macerated in appropriate amount of 60 percent ethyl alcohol. The resulting solution was kept overnight and filtered through Whatman filter paper no. 1 to obtain a clear solution. The colour of the solution was measured at 440 nm of Spectronic-20 using 60 percent aqueous alcohol as a blank.

3.2.5 Peroxide Value

Peroxide value was determined by method of AOAC (1984).

Reagents used

(i) Acetic acid : Chloroform solution (3:2 v/v)

(ii) Saturated potassium iodide solution.

(iii) 0.01N Sodium thiosulphate solution

(iv) Starch solution (1%). One g soluble starch was dissolved in cold distilled water to make thin paste, then boiling distilled water was added and boiled for one min while stirring. When completely dissolved, the volume was made to 100ml.

(v) Chloroform : Methanol solution (2:1 V/V)

Estimation :

Lipid content of 5g sample was extracted by keeping the sample overnight in chloroform : methanol (2:1 V/V) mixture. Next day the chloroform and methanol phase was evaporated and lipid phase was left in flask. Then to each flask 30 ml acetic acid : chloroform mixture was added and swirled to dissolve. After that, 0.5 ml of saturated potassium iodide, solution was added, kept for exactly 1 min with occasional shaking

and 30ml of distilled water was added. Then 0.5 ml of 1% starch solution was added and titrated with 0.01N sodium thiosulphate with vigorous shaking until all iodine from chloroform layer was released and blue colour just disappeared. The blank was run in the similar way.

$$\text{Peroxide value (meq/kg sample)} = \frac{S \times N \times 1000}{\text{g of sample}}$$

Where,

S = ml. sodium thiosulphate (blank corrected)

N = Normality of sodium thiosulphate solution.

3.2.6 Free fatty acids

Free fatty acids were determined by method of American Oil Chemists Society (AOCS) (1981).

Reagents used

(i) Sodium hydroxide (0.25N) Ten g NaOH was dissolved in water and made up to 1 lit with water.

(ii) Isopropyl alcohol (99%): Isopropyl alcohol (with added 2-3 drops of phenolphthalein indicator) was neutralized with 0.1N NaOH solution to a pink colour before adding to sample.

(iii) Phenolphthalein indicator solution (1% in ethanol)

Estimation

Lipid extracted from 5g sample was taken into conical flask. Fifty ml neutralised isopropyl alcohol was added to it and sample was dissolved completely. Phenolphthalein indicator was added and titrated against 0.25 N NaOH to pink colour end point which persisted for 30 seconds.

$$\% \text{ FFA} = \frac{\text{ml} \times N \times F \times 100}{\text{Sample wt} \times 1000}$$

Where,

ml = ml of NaOH required

N = Normality of NaOH solution

F = Equivalent weight (282) of oleic acid.

3.2.7 Fat acidity

The fat acidity was determined by the method of AOAC (1984)

Reagents

i) Benzene - alcohol - phenolphthalein (0.02%) : One litre benzene, one litre alcohol and 0.4 g phenolphthalein were mixed.

(ii) Potassium hydroxide (0.0178N) :

Potasium hydroxide (0.999g) was dissolved in water and made the volume to one litre.

Estimation

Ten g of sample was extracted with petroleum ether on Soxhlet apparatus. The solvent of the extract was completely evaporated on steam bath. The residue was dissolved in extraction flask with 50ml neutralized benzene - alcohol phenolphthalein solution and titrated with standard KOH (1g/lit) to orange pink. Blank titration was made on 50ml benzene alchol-phenolphthalein and this value was subtracted from titration value of the sample. Fat acidity was reported as mg of KOH required to neutralize free fatty acids from 100 g flour.

Fat acidity = 10 × (titrated value - Blank value)

3.3 Nutritional analysis of developed products

Developed products were analysed for their proximate composition i.e., moisture, energy, crude protein, fat, ash and β-carotene and total

carotenoids by using standard procedures of analysis detailed below :

3.3.1 Proximate analysis

3.3.1.1 Moisture : Moisture was determined by the method of A.O.A.C. (1990) by drying Sample at 100^{0}C in hot air oven to a constant weight and calculated as follows :

$$\text{Moisture (\%)} = W_{\backslash 2}/W_1 \times 100$$

Where,

W_1 = Weight (g) of sample

W_2 = Loss of weight (g)

3.3.1.2 Crude protein : Crude protein was determined by Microkjeldahl method (AOAC, 1990) by digesting samples with concentrated sulphuric acid using copper sulphate as a catalyst to convert nitrogen to ammonium ions. Alkali (40% sodium hydroxide solution) was added and the liberated ammonia distilled into an excess of boric acid solution. The distillate was titrated with hydrochloric acid to determine the ammonia absorbed in the boric acid.

Reagents used

Sulphuric acid: Concentrated, nitrogen free

Hydrochloric acid : 0.01N standardized

Boric acid solution : Dissolved 400g of boric acid in distilled water and diluted to one litre.

Sodium hydroxide solution (40%) dissolved 40 g carbonate free sodium hydroxide (NaOH) in distilled water and diluted to one litre.

Copper sulphate catalyst : Mixed copper sulphate ($CuSO_4 5H_2O$) and potassium Sulphate in the ratio of (1:9).

(PH: 4.5)

Mixed indicator solution : dissolved 2 g of methyl red and 1g of methylene blue or bromo cresol green in one litre of ehtanol. Stored in dark brown bottle.

Boiling regulators: Glass beads (for the digestion).

Procedure

Digestion : Placed a few boiling regulators in the Kjeldahl flask and pinch of the catalytic salt mixture. Transferred 2g of the sample to the Kjeldahl flask. Added 20 ml sulphuric acid and mixed by gently swirling the liquid. Digested the sample by boiling vigorously, occasionally rotating the flask until the liquid became clear and of a light blue green colour. Cooled and added 50 ml of water. Mixed and allowed to cool and diluted to make 100 ml in a volumetric flask.

Distillation : Added 10ml of the boric acid solution to 150ml conical flask. Added 2-3 drops of mixed indicator. Put the flask in contact with the condenser, Transferred 2ml of the aliquot to the distillation flask and rinsed the inlet with water. Poured 10ml of NaOH solution into the distillation apparatus and stoppered the inlet. Distilled the sample and titrated the contents of the flask with 0.01N HCl. Recorded the volume of HCl used.

Blank reading : Conducted a blank following above procedure except for addition of the sample.

Calculation: Crude protein was calculated by multiplying total nitrogen (%) with a factor of 6.25.

$$\text{Total nitrogen (\%)} = \frac{0.00014\ (V_1-V_2) \times \text{volume of aliquot made} \times 100}{\text{Volume of aliquot taken for distillation} \times W}$$

Where,

Weight (g) of the sample taken = W

Volume of aliquot made = 100 ml

Volume of aliquot taken for distillation = 2ml

Volume of HCl (N/100) used in titration for sample = V_1

Volume of HCl (N/100) used in titration for blank = V_2

3.3.1.3 Total fat : Crude fat was estimated using Soxhlet method (A.O.A.C. 1990)

Reagents used

Petroleum ether (boiling range 40-60°C)

Procedure

Took 5g of well ground dried sample in an extraction thimble. Placed the thimble in the extractor and connected weighed flasks containing 100 ml petroleum ether. Connected the extractor to a reflux condenser and extracted the sample under reflux for 5-6 hours. Evaporated the petroleum ether extract to dryness and added 2 ml acetone. Blow air gently into the flask to remove the last traces of solvent. Dried the flask containing the fat residue in hot air oven at 100°C for 5 min. Cooled in a desiccator and weighed.

Calculations

$$\text{Extractable fat (\%)} = \frac{W_3-W_2 \times 100}{W_1}$$

Where

W_1 = Weight (g) of the sample taken

W_2 = Weight (g) of the empty flask, and

W_3 = Weight (g) of flask with fat.

3.3.1.4 Ash : Ash content was determined by charring the sample thoroughly and then ashing at 550°C in a Muffle furnace (A.O.A.C. 1990). Ash content was calculated using following formula :

$$\text{Ash (\%)} = W_2/W_1 \times 100$$

Where,

W_1 = Weight (g) of sample taken, and

W_2 = Weight (g) of ash

3.3.1.5 Gross energy (Gopal Krishna and Ranjhan, 1980)

Gross energy was determined by Isothermal Bomb Calorieмter.

Reagents used

1. Benzoic acid (heat of combustion 6.318 kcal/g)

2. Standard alkali solution: The washings from an oxygen bomb test must be titrated with a standard alkali solution to determine the acid correction. Usually 0.0725 N sodium carbonate solution is recommended. This is prepared by dissolving 3.84 g. Na_2CO_3 in water and diluting to one litre.

3. Methyl orange or methyl red indicator.

Procedure

1. Calorimeter bucket was filled with two litres of distilled water. Two-third of thecalorimeter jacket was filled with tap water.

2. The difference of the temperature between the outer jacket and inner bucket was maintained at least 2°C (temp of inner bucket should be lower than the outer jacket.

3. Weighed 1 g of sample in to the bomb.
4. Filled the bomb with oxygen at 25 atmosphere.
5. The filled bucket was kept in the jacket with the long axis of the oval, locating boss in the bottom positioned nearest the operator.
6. Attached the thrust terminal to the bomb electrode.
7. Placed the cover on the jacket with the thermometer toward the operator.
8. Locating pin at the rear of the cover should fit in to the hole in the top rim of the jacket.
9. Motor of the calorimeter was runned for 5 min without taking readings in order to attain thermal equilibrium.
10. Calorimeter temperature was recorded to the nearest 0.005°F at one minute interval for exactly five minutes.
11. Then pressed the button on the ignitition unit to fire the charge at the start of the sixth minute, recorded the exact time and temperature at the firing point.
12. The difference between successive readings were noted and readings continued at one minute intervals, until the rate of temeprature change becomes uniform and constant over a period of five minutes.
13. After reaching the constant temperature stirrer was stopped and bomb was removed.
14. Bomb was kept aside for ½ an hour.

15. Interior surface of the bomb was washed and the content was titrated against standard alkali solution i.e. Na_2CO_3.

16. Amount of the Na_2CO_3 used for the titration was noted.

Calculations

$$Hg = \frac{tw - e_1 - e_2 - e_3}{m}$$

$e_1 = C_1$

$e_2 = (14)\ (C_2)\ (m)$

$e_3 = 2.3\ (C_3)$

$t = tc - ta - r_1(b-a) + r_2\ (c-b)$

a = time of firing

b = time (to nearest 0.1 minute) when the temperature reaches 60 per cent of the total rise

c = Time at beginning of period (after the temperature rise) in which the rate of temperature change has become constant.

ta = Temperature at time of firing, corrected for thermometer scale error.

tc = Temperature at time c, corrected for thermometer scale error

r_1 = Rate (temp. units/minute) at which temperature was rising during the five minutes period before firing

r_2 = Rate (temp. units/minute) at which the temperature was falling during the five minutes period after time c)

c_1 = Millilitres of standard alkali solution used in the acid titration

c_2 = Percentage of sulfur in the sample

c_3 = Centimetres of fuse wire consumed in firing

W = Energy equivalent of the caloriemter in calories per degree fahrenheit or centigrade

m = Mass of sample in grams

3.3.2 β–carotene and total carotenoids.

β–carotene and total carotenoids of the developed products were estimated as described under (3.2.3.)

3.4 Acceptability and storage of developed products

3.4.1 Acceptability of the products

The developed products were evaluated organoleptically by semitrained persons using 9 point Hedonic scale.

3.4.2. Storage studies

The nine selected products were packed in polythene bags separately and sealed. These packets were kept in incubator where the temperature was maintained at 37^0C for 45 days. Samples were drawn at 15 days interval and analysed for sensory evaluation and nutritional analysis.

3.4.3 Sensory evaluation

The developed products were valued organoleptically by semitrained persons using 9 point Hedonic scale at 15 days interval.

3.4.2.2 Nutritional evaluation upon storage: Selected products were analysed for changes in non enzymatic browning, peroxide value, free fatty acids, fat acidity, β–carotene and total carotenoids.

(i) β–carotene and total carotenoids were determined by the method described in 3.2.3

(ii) Non enzymatic browning was determined by the method described in 3.2.4.

(iii) Peroxide value was determined by the method described in 3.2.5.

(iv) Free fatty acid were determined by the method described in 3.2.6.

(v) Fat acidity was determined by the method described in 3.2.7.

3.5 Locale of research

Easy assessability and closer proximity of the locale is desirable for conducting the feeding trial. Government Primary School, Canal Colony, Hisar was selected as the locale for this study as its preliminary survey indicated that it was quite adequate in size. The students belonged to lower socio-economic group.

3.6 Nutritional Status assessment

It may be defined as the condition of health as influenced by the intake and utilization of nutrients (Caliendo, 1979)

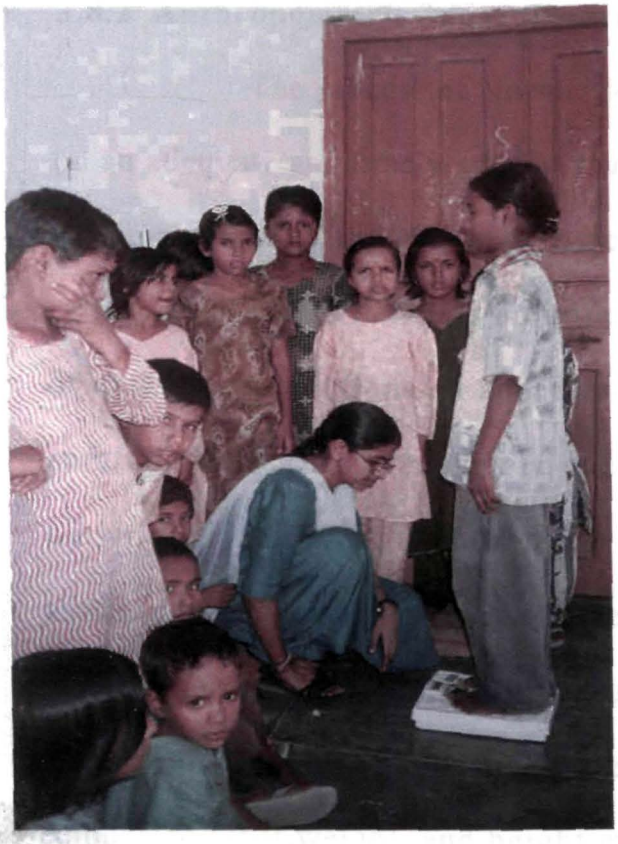
The nutational status of children was assessed in terms of their dietary intake, anthropometric measurements and clinical and biochemical tests, detail of which is given below :

3.6.1 Dietary assessment

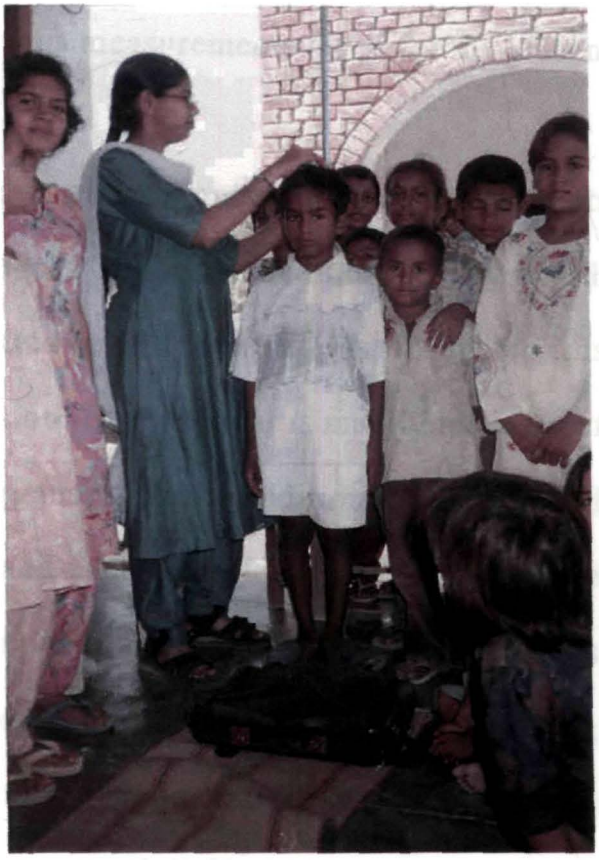
Dietary survey was conducted for three consecutive days using 24 hour recall method during the study period.

All the mothers were oriented about the procedure and the purpose of diet survey. Maximum efforts were made to obtain correct information from the mothers. Initial orientation has helped them to recall and show the foods consumed in accurate amounts.

Nutrient content of the child's diet in terms of energy, protein, fat and vitamin A were calculated using food consumption tables (Gopalan *et al.*, 1996).



Taking anthropometric measurements of the subjects (height and weight)



3.6.2 Anthropometric measurements

The process of Normal growth and development is dependent on an adequate and timely supply of nutrients. Undernutrition is reflected in impairment of growth, and therefore useful indicator of nutritional status. Growth retardation is an important and quantifiable manifestation of undernutrition (Gopalan and Chatterjee, 1985). Growth assessed by anthropometric measurements is one of the most sensitive indicators of nutritional status of children. It is possible to use a variety of anthropometric measures to assess the growth of a child. Among the most studied are : weight, height, arm circumference, skinfold thickness, chest circumference and head circumference. Waterlow *et al.* (1977) emphasized that weight and height measurements together are useful to understand the dynamic of malnutrition, distinguishing between current and chronic malnutrition. The various measurements taken for the present study were as follows :

Weight: Weight is the key anthropometric measurement. Its potential value especially for children is appreciated not only by health personnel, but often by less educated or illiterate parents, for whom it is useful as a source of health education. Body weight is mainly made up of muscles, fat, bones and internal organs, with the addition in pathological circumstances of oedema, ascites and even the helminth burden in severe ascariasis. It is a good indicator of present nutritional status and is concerned with determining degrees of underweight, principally resulting from varying levels of protein-calorie malnutrition. It is not usually concerned with the detection of obesity (Jelliffee 1966).

Indian made weighing balance (krups) calibrated in kilograms and grams, was used for weighing by methods described by Jelliffee (1966). This was standardized with known weights before use and kept on a flat surface. The respondent was made to stand barefooted on the platform of the balance without touching any other surface or object, with minium clothes. The pointer on the balance scale was adjusted to zero before each weighing. The recorded weights were compared with ICMR (1989) standards. Weight was recorded three times and their mean was taken.

Height : The height of an individual is made up of the sum of four components, i.e. legs, pelvis, spine and skull. It is affected by long term nutritional deprivation and considered an index of chronic and long duration malnutrition (Jelliffe, 1966). Height was measured according to the method described by Jelliffe (1966). A vertical measuring rod calibrated in cm made by western surgical manufacturers was fixed to a wall having plain floor. The bare footed respondent was made to stand erect on platform with feet parallel and with heels, buttocks, shoulders and back of head touching the upright. The head was held comfortably erect, with the lower border of the orbit in the same horizontal plane. The arms were hanging at the sides in a natural manner. The head piece was gently lowered. crushing the hair and making contact with the top of the head. Height was measured to the nearest 0.1 cm on the measuring rod. Height measurement was repeated three times for each individual, then mean was taken and compared with Indian standards.

3.6.3 Clinical assessment

Clinical examination of an individual is the least sensitive method used to evaluate individuals' nutritional status.

For the manifestation of clinical signs and symptoms of vit. A deficiency and presence of infections and other illness, a medical practitioner was associated with the work.

3.6.4 Biochemical assessment

Serum retinol levels were observed before and after supplementation

The absorption at 460 nm and the difference in absorption at 328 nm before and after irradiation with ultra violet light (between wavelengths 310-400 nm) can be used as a measure of carotene and vit. A, respectively.

Reagents used

(i) Potassium hydroxide (1N) : weighed 56.10 and made volume of 1 ltr with distilled water

(ii) Ethanol

(iii) Alcoholic KOH : 10 ml of 1N KOH was taken and made volume of 100ml with ethanol (~~should be~~ freshly prepared)

(iv) Petroleum ether (B.P. 62)

(v) Anhydrous sodium sulphate

(vi) Cyclohexane.

Procedure

Extraction and saponification: Pippetted 3-4 ml of serum into a glass stopped tube, added an equal volume of alchoholic KOH and mixed well. Incubated the tube in water bath at 60-65°C for 20 min. Removed and allowed to cool to room temperature. Then extracted the unsaponifiable

matter three times with 10 ml of light petroleum ether. Pooled and washed the petroleum ether extract with water to remove the alkali. Passed through anhydrous sodium sulphate and evaporated to dryness under vacuum at 40^{0}C. Dissolved the dry residue immediately in 3-4 ml cyclohexane (same volume as serum).

Measured the optical density (OD) of the cyclohexane extract at 328 mm in spectrophotometer. Transferred the solution to a soft glass tube with a stopper and irradiated under Ultra violet light and measure the OD again at 328 nm. The difference in the OD is taken as a measure of concentration of retinol in serum.

Note: The ultra violate lamp should be turned on 10 min before use the tube should be kept at a distance of 20 cm from the lamp. The OD at 328 nm is again read and the difference in OD is taken as a measure of retinol in the solution.

Calculations

E 1% 328 of retinol, vit. A in cyclohexane = 1550

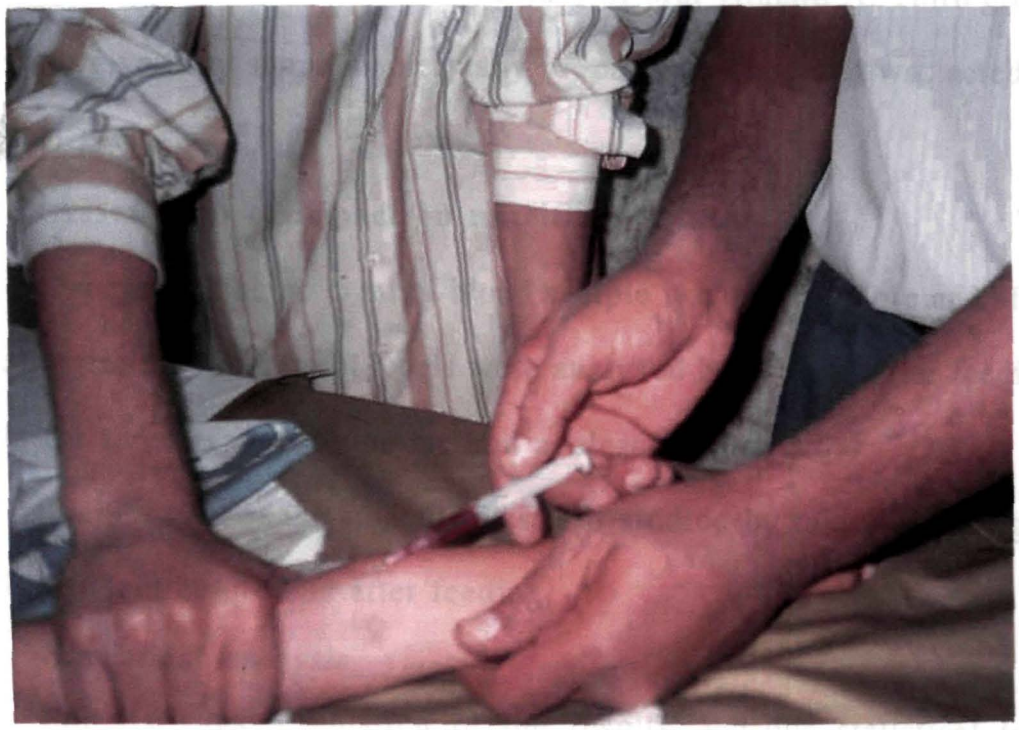
E 1% at 460 for β-carotene in cyclohexane = 2100

Retinol /vitamin A in 100 ml serum = (E328 initial - E 328 irradiated) × 645

3.7 Selection of supplements and subjects for feeding trials

Based on preliminary survey report of Government Primary School, Canal Colony, Hisar, a list of children (7-9 yrs old) was prepared. Thirty children were selected randomly from the surveyed children. These were divided into three groups of 10 children so that each group had similar mean dietary intake and anthropometric measurements one group was kept for feeding trials and one group was given single dose of oral vitamin A. Third group was not given any supplementary or prophylactic dose and

Feeding supplementary foods to the subjects



Taking blood samples from the subjects

served as control group. Supplements were selected based on their overall acceptability, convenience and feasibility of preperation.

3.8 Feeding trials and its impact on Nutritional status

3.8.1 Feeding trials

The first group was given one particulars supplement for each day. The supplements Biscuits, Nankhatai and Nutritious ladoo were selected and given for feeding by alternating them in each day. Each child received a packet containing 35.6g of Biscuit or 31.25 g of Nankhatai or 36 g of Nutritious ladoo which ultimately provides 1323 µg of βcarotene per day. Children were instructed to eat the given supplements in front of the investigator during their lunch break. Home visits were made to check up any problem regarding digestion or difficulty with intake of supplementary foods. Second group was given single dose of oral vitamin A. Third group was not given any supplementary/any prophylatic dose and was acted as control group.

3.8.2 Assessment of impact on nutritional status

From each subject 5 ml of blood sample was taken before and after feeding trial. Serum retinol levels were analysed before and after feeding trials for three groups by the method as described in 3.6.4.

Wegiht gain of the students was also studied by taking the weight of the student before and after feeding.

3.9 Statistical analysis

For statistical evaluation of the results, various statistical tests used were as under (Chao, 1974).

Mean

$$\text{Mean} = \frac{\Sigma x}{n}$$

Where,

Σx = sum of observations

n = number of observations

Standard deviation

$$\text{S.D.} = \sqrt{\frac{\Sigma x^2}{n} - \left(\frac{\Sigma x}{n}\right)^2}$$

Σx^2 = sum of squares of observations

Paired 't' test

It was used to compare pre and post exposure mean scores of experimental group.

$$\text{'t'} = \frac{\bar{x} - \mu}{S} \text{ at n-1 degree of freedom}$$

$$S = \frac{SD}{\sqrt{n}}$$

Where,

$$SD = \frac{1}{n-1} \Sigma(x-\bar{x})^2$$

Unpaired 't' test

$$\text{'t'} = \frac{\bar{x} - \bar{y}}{S\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} \text{ at } n_1+n_2 - 2 \text{ degree of freedom}$$

$$S^2 = \frac{\Sigma(X_i - \bar{X})^2 + \Sigma(Y_i - \bar{Y})^2}{n_1 + n_2 - 2}$$

Where,

x_i = i^{th} observation of experimental group

y_i = i^{th} observation of control group

n_1 = Number of observations in experimental group

n_2 = Number of observations in control group

Analysis of variance

Data of nutritional evaluation were subjected to statistical analysis for analysis of variance in a completely randomized design according to standard method (Panse and Sukhatme, 1961).

CHAPTER- 4

RESULTS AND DISCUSSION

The present study was conducted to develop supplements using crude palm oil and investigate their effect on storage, and on nutritional status of school children. A dietary survey of children (n=30) from Govt. School, Canal Colony was conducted.. Their anthropometric measurements were taken and clinical and biochemical assessment was carried out with the help of medical practitioner. Three groups, out of the respondents were selected for further study. Diets of one group were supplemented with three developed supplements and one group was kept as control group. One group was given one dose of oral vitamin A. The results obtained in the present study followed by the discussion of the same are presented under following headings:

4.1 Nutritional evaluation of crude palm oil

4.2 Development of supplementary foods

4.3 Nutritional analysis of developed products

4.4 Acceptability and storage of developed products

4.5 Nutritional status assessment

4.6 Feeding trial and its impact on nutritional status

4.1 Nutritional evaluation of crude palm oil

Crude palm oil was analysed for moisture, peroxide value, fat acidity, free fatty acids, browning, β-carotene and total carotenoids. The moisture cotnent of crude palm oil was 0.31 ± 0.01 per cent, the peroxide value of the crude palm oil was not found. It may be due to the freshness of the sample. Fat acidity was found to be 31.00 ± 1.00 per cent, free fatty acids 0.42 per cent and browning was found to be 0.008 O.D.

The most important components β-carotene and total carotenoide were found to be 336 ± 33.68 and 538.54 ± 11.64, respectively (Table.4.1).

The trend of above nutrients were reported to be similar by Khan *et al.* (1998).

4.1.1 Fatty acid composition of crude palm oil

The crude palm oil contained nearly equal amounts of saturated and unsaturated fatty acids, i.e. 49.29 per cent and 55.20 per cent, respectively. The major fatty acids of crude palm oil were palmitic (C 16:0) and oleic (C 18:1) acids, whereas linoleic (C 18:2) and stearic (C 18:0) acids, were found to be 11.75 and 4.52 per cent, respectively. Lauric (C 12:0) and Myristic (C 14:0) acids were found to be in minor quantities (Table.4.2) .

Fatty acid composition of crude palm oil was also found in similar ratio by Tan and Ohe (1981), Armugan *et al.* (1989) and Manorma (1992a) and Malaysian palm oil information bulletin (2000).

Table 4.1. Physicochemical properties of crude palm oil

Physicochemical property	Mean ± S.E.
Moisture (%)	0.31 ± 0.01
Peroxide value (meq/kg)	-
Fat acidity (%)	31.00 ± 1.00
Free fatty acids (%)	0.42 ± 0.00
Non-enzymatic browning (O.D.)	0.008 ± 0.00
β-carotene (μg/g)	336.00 ± 33.68
Total carotenoids (μg/g)	538.54 ± 11.64

Values are mean ± S.E.

Table 4.2. Fatty acids composition of crude palm oil

Fatty acid		Percentage
Lauric	C 12:0	0.56
Myristic	C 14:0	1.04
Palmitic	C 16:0	43.20
Stearic	C 18:0	4.52
Oleic	C 18:1	43.45
Linoleic	C 18: 2	11.75

4.2 Development of supplementary foods

4.2.1 Recipe selection for laboratory preparations

Various recipes making use of commonly available ingredients were considered for development and these suplements were further subjected to organoleptic evaluation.

All the selected recipes provided adequate protein and energy. All these being snacks, were expected to be more popular and acceptable among children. Also all these had a shelf life of at least one week. So these could be easily prepared on weekly basis for feeding trials and these recipes are based on simple home scale techniques which requires less time, less fuel and less labour.

4.3 Nutritional analysis of developed products

The developed supplements were analysed for moisture, fat, protein, energy and ash.

The moisture content of the products ranged from 0.03 ± 0.00 to 41.78 ± 0.75 per cent being highest in lemon rice and lowest in namkeen para (Table 4.3).

Besan burfi has highest (12.34 ± 0.63) and suji ladoo had the lowest (4.37 ± 0.00) content of protein (Table 4.3). Fat per cent was highest for nankhatai (33.74 ± 0.45) while lemon rice had the lowest (17.24 ± 0.17).

Besan burfi has highest (3.93 ± 0.15) and suji ladoo had the lowest (0.62 ± 0.01) content of ash.

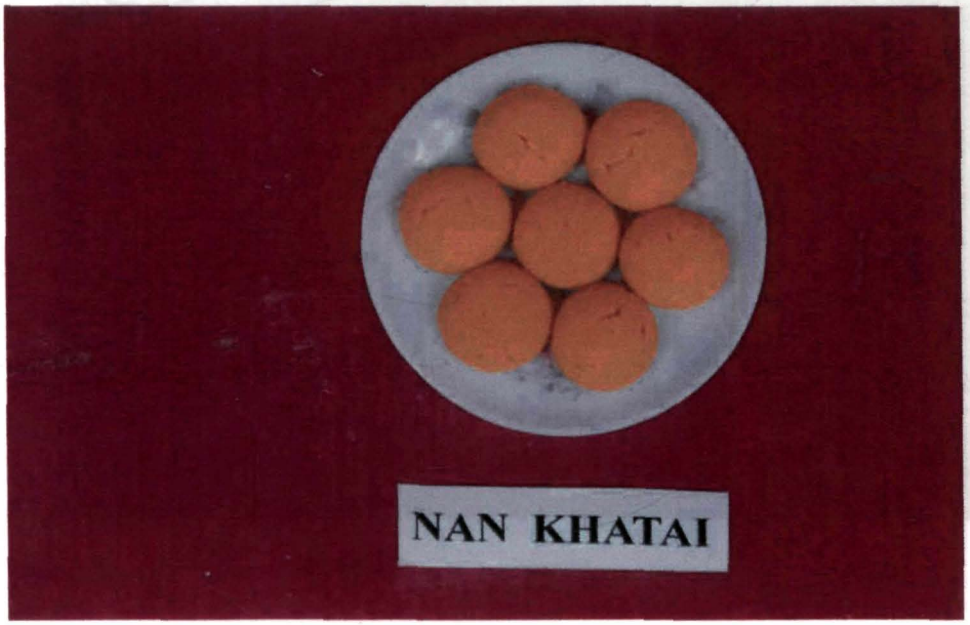
When the important nutrient energy was compared among the products,nutritious ladoo was found to be good source of energy with 639.43

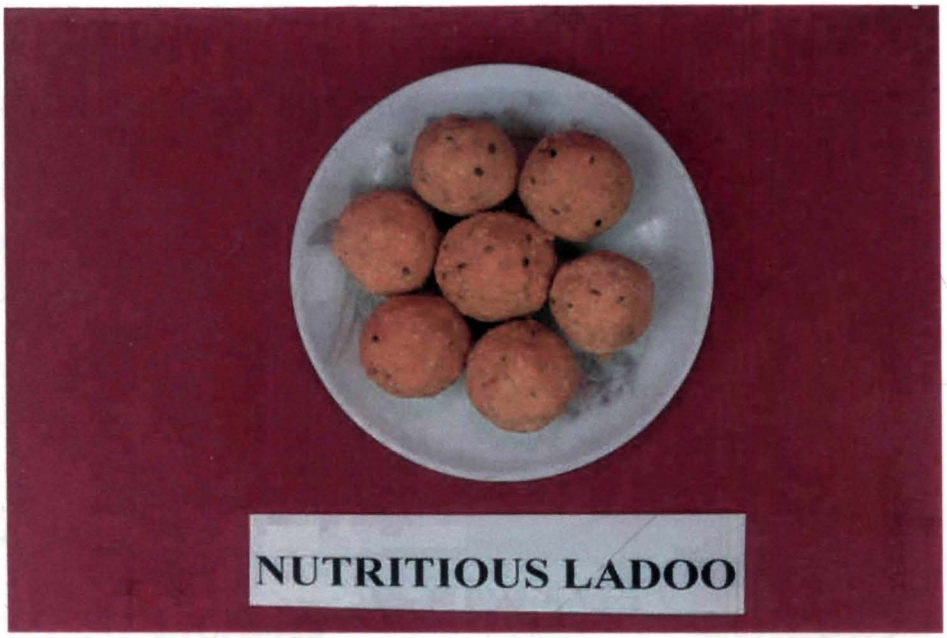
Table 4.3. Chemical composition of developed supplements (Per cent dry matter basis)

Products	Moisture	Protein	Fat	Ash	Energy (K.cal)	Fresh weight basis (µg/g) β-carotene	Total carotenoids
Biscuit	1.00^{H} ±0.01	8.56^{DE} ±0.00	31.67^{B} ±0.61	2.02^{C} ±0.04	552.67^{C} ±0.90	38.84^{B} ±0.17	56.80^{B} ±0.18
Nankhatai	1.19^{H} ±0.02	8.78^{DE} ±0.03	33.74^{A} ±0.45	1.38^{DE} ±0.01	546.33^{C} ±2.74	41.64^{A} ±0.15	64.11^{A} ±0.19
Besan burfi	2.43^{G} ±0.06	12.34^{A} ±0.63	19.88^{G} ±0.07	3.93^{A} ±0.15	564.02^{B} ±4.34	27.49^{D} ±0.17	40.09^{C} ±0.30
Nutritious *ladoo*	0.47^{H} ±0.01	10.57^{C} ±0.00	21.25^{F} ±0.18	1.25^{E} ±0.03	639.43^{A} ±5.81	33.88^{C} ±0.12	55.59^{B} ±0.32
Suji ladoo	5.58^{E} ±0.05	4.37^{F} ±0.00	21.95^{F} ±0.22	0.62^{F} ±0.01	475.00^{F} ±2.50	23.85^{F} ±0.10	34.48^{D} ±0.18
Cake	19.90^{D} ±0.55	8.75^{DE} ±0.00	25.02^{E} ±0.21	0.77^{F} ±0.01	513.04^{E} ±2.49	33.24^{C} ±0.31	30.91^{E} ±0.12
Doughnuts	4.37^{F} ±0.05	7.08^{E} ±0.00	21.91^{F} ±0.29	0.69^{F} ±0.02	529.59^{D} ±0.84	21.41^{G} ±0.12	31.60^{E} ±0.10
Lemon rice	41.78^{A} ±0.75	10.76^{B} ±0.00	17.24^{I} ±0.17	3.01^{B} ±0.10	284.04^{J} ±9.30	14.34^{I} ±0.09	23.03^{F} ±1.66
Namkeen para	0.03^{H} ±0.00	7.00^{D} ±0.00	20.17^{G} ±0.54	1.47^{DE} ±0.01	385.34^{G} ±2.97	28.05^{D} ±0.06	41.45^{C} ±0.04
Sweet and salty biscuit	3.20^{G} ±0.02	6.38^{F} ±0.00	27.47^{C} ±2.44	2.00^{C} ±0.28	336.26^{H} ±2.18	20.94^{D} ±0.05	30.49^{E} ±0.03
Poha	32.13^{C} ±1.03	11.28^{B} ±0.00	18.52^{H} ±0.15	1.40^{DE} ±0.11	312.44^{I} ±2.16	23.63^{F} ±0.09	34.70^{D} ±0.09
Upma	38.44^{B} ±0.16	11.28^{B} ±0.00	26.51^{D} ±0.22	1.58^{D} ±1.22	287.87^{J} ±2.65	21.04^{GH} ±0.02	31.21^{E} ±0.06
C.D. (P<0.05)	1.15	0.52	0.91	0.21	11.15	0.40	1.44

Superscripts with different letters differs significantly.

CRUDE PALM OIL BASED PRODUCTS




NUTRITIOUS LADOO


SUJI LADOO
BESAN BURFI

POHA


CAKE


SNACK ITEM
DOUGH NUTS

LEMON RICE

UPMA

± 5.81 K.cal per 100 g of sample and lemon rice has lowest energy value i.e. 284.04 ± 9.30 K.cal.

Nankhatai had highest amount of β-carotene and total carotenoids having 41.64 ± 0.149 and 64.11 ± 0.193 µg per gram, respectively, followed by lemon rice with 14.34 ± 0.085 µg per gram β-carotene and 23.03 ± 1.66 µg per gram total carotenoids.

It is evident from the data that the developed products were concentrated sources of β-carotene and total carotenoids.

4.4 Acceptability and storage of developed products

4.4.1 Acceptability of developed products

The recipes prepared by incorporating crude palm oil were organoleptically evaluated in terms of colour, flavour, texture, appearance, taste and overall acceptability (Table 4.4).

Colour

When the colour of all the developed products were compared, the scores ranged from 'Like mdoerately' to like extremely. Among all the products lemon rice scored more i.e. 8.1 ± 0.23 followed by Poha (7.90 ± 0.17), besan burfi (7.80 ± 0.24). It may be due to the natural yellow colour of the products.The other products scored less. It may be due to the use of crude palm oil which imparted yellow colour to the product.

Appearance

The organoleptical scores of appearance of the products ranged from 8.0 to 7.2 i.e. 'Like extremely' to like moderaly. Among all the products appearance of lemon rice scored high (8.00 ± 0.25) followed by besan burfi (7.90 ± 0.23), poha (7.80 ± 0.20) and nankhatai (7.60 ± 0.26).

Table 4.4. Organoleptic acceptability of developed supplements using crude palm oil

Name of the product	Colour	Appearance	Flavour	Texture	Taste	Overall acceptability
Biscuit	7.70^{AB} (±0.21)	7.20^{A} (±0.29)	7.60^{AB} (±0.16)	7.60^{ABC} (±0.22)	7.80^{A} (±0.13)	7.58^{AB} (±0.18)
Nankhatai	7.70^{AB} (±0.21)	7.60^{A} (±0.27)	7.20^{AB} (±0.27)	6.70^{C} (±0.30)	7.50^{AB} (±0.17)	7.34^{AB} (±0.21)
Nutritious *ladoo*	7.50^{AB} (±0.22)	7.20^{A} (±0.33)	7.30^{AB} (±0.30)	6.80^{BC} (±0.33)	7.40^{AB} (±0.31)	7.24^{AB} (±0.27)
Besan burfi	7.80^{AB} (±0.25)	7.90^{A} (±0.23)	7.50^{AB} (±0.31)	7.50^{ABC} (±0.27)	7.20^{AB} (±0.36)	7.58^{AB} (±0.25)
Suji ladoo	7.30^{AB} (±0.33)	7.30^{A} (±0.34)	7.30^{AB} (±0.30)	7.30^{ABC} (±0.22	7.40^{AB} (±0.27)	7.32^{AB} (±0.26)
Cake	7.60^{AB} (±0.37)	7.40^{A} (±0.37)	7.70^{AB} (±0.26)	7.60^{ABC} (±0.27)	7.50^{AB} (±0.34)	7.56^{AB} (±0.29)
Doughnuts	7.50^{AB} (±0.22)	7.50^{A} (±0.22)	7.50^{AB} (±0.27)	7.00^{BC} (±0.421	7.00^{AB} (±0.26)	7.30^{AB} (±0.23)

Name of the product	Colour	Appearance	Flavour	Texture	Taste	Overall acceptability
Sweet and salty biscuits	7.20^{B} (±0.20)	7.20^{A} (±0.20)	6.70^{B} (±0.56)	7.10^{BC} (±0.28)	6.60^{B} (±0.52)	6.96^{B} (±0.30)
Namkeen para	7.70^{AB} (±0.21)	7.50^{A} (±0.22)	7.10^{AB} (±0.50)	6.90^{BC} (±0.38)	7.10^{AB} (±0.53)	7.26^{AB} (±0.34)
Lemon rice	8.10^{A} (±0.23)	8.00^{A} (±0.26)	7.90^{A} (±0.18)	8.10^{A} (±0.23)	7.70^{AB} (±0.33)	7.96^{A} (±0.21)
Poha	7.90^{AB} (±0.18)	7.80^{A} (±0.20)	7.80^{AB} (±0.20)	7.70^{AB} (±0.26)	8.10^{A} (±0.31)	7.86^{A} (±0.22)
Upma	7.60^{AB} (±0.22)	7.50^{A} (±0.22)	7.10^{AB} (±0.28)	7.40^{ABC} (±0.27)	7.20^{AB} (±0.36)	7.36^{AB} (±0.23)
CD ($P<0.05$)	0.51	0.54	0.75	1.00	1.08	0.65

Values are mean±S.E. of 10 panelists.
Superscripts with different letters differs significantly.

Flavour

The crude palm oil had pungent smell and it was subsided by the spices which were used in the development of the products. So the flavour of the products like lemon rice, poha and cake were scored high i.e. 7.90, 7.80 and 7.70. The scores ranged from "Like slightly to like moderately".

Texture

When texture of the products were compared, the texture of the lemon rice was accepted mostly (8.1 ± 0.23) followed by poha (7.70 ± 0.26), biscuit (7.60 ± 0.22), cake (7.60 ± 0.26) and besan burfi (7.50 ± 0.34). The rest of the products were in the range of "like moderately to like slightly".

Taste

Taste was the major organoleptic characteristic which influences the desire to take the product. When this parameter was compared it was found that poha (8.10 ± 0.31) was accepted mostly followed by biscuit (7.80 ± 0.13), lemon rice (7.70 ± 0.33) and nankhatai, cake (7.50 ± 0.16).

Overall acceptability

Among all the products, the products like lemon rice (7.96 ± 0.21), poha (7.86 ± 0.21), biscuit (7.58 ± 0.18) and besan burfi (7.58 ± 0.22), sweet and salty biscuit was scored low (6.96 ± 0.3).

4.4.2 Storage studies

Changes in organoleptic and nutritional quality of stored supplementary foods were studied to evaluate the acceptability and shelf life of these stored supplementary foods. The products which could be stored for sometime were set for storage studies.

4.4.2.1 Sensory evaluation

The overall acceptability in terms of colour, flavour, taste, texture and appearance was judged by a panel of ten judges. The results reveal that all the foods prepared were found to be acceptable in terms of colour, flavour, taste, texture and appearance during all the periods of storage. It was osberved that overall acceptability score of biscuit, cake, besan buri, was maximum (7.56) acceptability score and it was in like moderately category. The overall acceptability of the developed products differ significantly from each other during storage period. Minimum overall acceptability scores were observed in sweet and salty biscuit on 45th day. The trend in declining the organoleptic parameters i.e. colour, appearance, flavour, texture, taste was observed similar in all the products during entire storage period (Table 4.5).

The scores for texture and taste of the developed products from 30th day were in 'dislike moderately' category and differ significantly ($P<0.05$) from 0 and 15 days.

Thus, it may be concluded that organoleptic characteristics of all the supplements were not affected till one month of storage.

4.4.2.2 Nutritional evaluation upon storage

The products which are organoleptically good, consumes less time in the preperation and provides maximum β-carotene were selected for nutritional evaluation. Nutritional evaluation was done by the parameters like browning, peroxide value, fat acidity, free fatty acids, β-carotene and total carotenoids.

Table 4.5. Effect of storage on organoleptic characteristics of products based on crude palm oil

Name of the product	Number of days																							
	Colour				Appearance				Flavour				Texture				Taste				Overall acceptability			
	0	15	30	45	0	15	30	45	0	15	30	45	0	15	30	45	0	15	30	45	0	15	30	45
Biscuit	7.7^{AB} (±0.21)	7.3^{AB} (±0.15)	7.2^{BDC} (±0.13)	7.0^{AB} (±0.26)	7.2^{A} (±0.29)	7.4^{A} (±0.16)	7.0^{BDC} (±0.15)	7.2^{A} (±0.20)	7.6^{AB} (±0.16)	7.3^{A} (±0.21)	6.6^{A} (±0.22)	6.3^{A} (±0.15)	7.6^{ABC} (±0.22)	7.2^{A} (±0.20)	6.6^{A} (±0.22)	5.9^{A} (±0.10)	7.8^{A} (±0.13)	7.3^{A} (±0.21)	6.2^{AB} (±0.29)	4.9^{A} (±0.28)	7.6^{AB} (±0.18)	7.3^{A} (±0.14)	6.7^{AB} (±0.12)	6.3^{A} (±0.09)
Nankhatai	7.7^{AB} (±0.21)	7.5^{AB} (±0.29)	7.4^{ABC} (±0.16)	6.6^{ABC} ±0.22)	7.6^{A} (±0.27)	7.0^{A} (±0.21)	7.6^{A} (±0.16)	6.7^{AB} (±0.21)	7.2^{AB} (±0.25)	7.3^{A} (±0.21)	6.8^{A} (±0.13)	5.1^{B} (±0.55)	6.7^{C} (±0.30)	7.1^{A} (±0.10)	6.6^{A} (±0.16)	4.1^{B} (±0.60)	7.5^{AB} (±0.17)	7.3^{A} (±0.15)	5.8^{AB} (±0.29)	3.4^{B} (±0.54)	7.3^{AB} (±0.21)	7.2^{AB} (±0.13)	6.8^{AB} (±0.12)	5.2^{B} (±0.35)
Nutritious *ladoo*	7.5^{AB} (±0.2)	7.4^{A} (±0.22)	7.3^{A} (±0.13)	6.4^{CB} (±0.16)	7.2^{A} (±0.33)	7.1^{A} (±0.31)	7.5^{AB} (±0.22)	6.2^{BC} (±0.20)	7.3^{AB} (±0.30)	7.2^{A} (±0.49)	7.0^{A} (±0.21)	5.9^{AB} (±0.18)	6.8^{BC} (±0.33)	6.8^{A} (±0.36)	6.9^{A} (±0.23)	4.1^{B} (±0.31)	7.4^{AB} (±0.30)	6.5^{AB} (±0.34)	6.8^{A} (±0.33)	3.0^{B} (±0.30)	7.2^{AB} (±0.27)	7.0^{A} (±0.29)	7.2^{A} (±0.15)	5.1^{B} (±0.14)
Besan burfi	7.8^{AB} (±0.25)	6.6^{A} (±0.30)	-	-	7.9^{A} (±0.23)	6.0^{B} (±0.36)	-	-	7.5^{AB} (±0.31)	5.1^{C} (±0.48)	-	-	7.5^{ABC} (±0.31)	4.1^{B} (±0.46)	-	-	7.2^{AB} (±0.36)	5.3^{C} (±0.33)	-	-	7.6^{AB} (±0.22)	5.4^{C} (±0.26)	-	-
Suji ladoo	7.3^{AB} (±0.33)	7.2^{AB} (±0.33)	6.8^{D} (±0.25)	-	7.3^{A} (±0.33)	7.1^{A} (±0.28)	6.8^{DC} (±0.20)	-	7.3^{AB} (±0.30)	6.5^{AB} (±0.31)	6.6^{A} (±0.30)	-	7.3^{ABC} (±0.21)	6.8^{A} (±0.20)	4.2^{B} (±0.42)	-	7.4^{AB} (±0.27)	6.6^{AB} (±0.16)	6.2^{AB} (±0.39)	-	7.3^{AB} (±0.25)	6.8^{AB} (±0.22)	6.1^{DC} (±0.23)	-
Cake	7.6^{AB} (±0.37)	-	-	-	7.4^{A} (±0.37)	-	-	-	7.7^{AB} (±0.26)	-	-	-	7.6^{ABC} (±0.27)	-	-	-	7.5^{AB} (±0.34)	-	-	-	7.6^{AB} (±0.28)	-	-	-
Sweet & salty biscuit	7.2^{B} (±0.20)	7.1^{AB} (±0.23)	7.0^{ABC} (±0.17)	6.3^{C} (±0.15)	7.2^{A} (±0.20)	7.1^{A} (±0.23)	7.1^{ABC} (±0.18)	6.1^{C} 0.18)	6.7^{B} (±0.56)	6.0^{BC} (±0.52)	6.8^{A} (±0.13)	5.1^{B} (±0.28)	7.1^{BC} (±0.28)	6.5^{A} (±0.27)	4.3^{B} (±0.54)	3.9^{B} (±0.31)	6.6^{B} (±0.52)	5.7^{BC} (±0.47)	4.1^{C} (±0.35)	2.9^{B} (±0.38)	6.9^{B} (±0.30)	6.5^{B} (±0.29)	5.9^{D} (±0.16)	4.9^{B} (±0.20)
Namkeen para	7.7^{A} (±0.21)	7.6^{AB} (±0.10)	7.5^{AB} (±0.15)	7.1^{A} (±0.23)	7.5^{A} (±0.22)	6.8^{A} (±0.20)	7.2^{ABC} (±0.20)	6.9^{A} (±0.18)	7.1^{AB} (±0.50)	6.2^{ABC} (±0.51)	6.4^{A} (±0.34)	5.7^{AB} (±0.26)	6.9^{BC} (±0.38)	6.4^{A} (±0.43)	6.1^{A} (±0.41)	4.2^{B} (±0.36)	7.1^{AB} (±0.52)	6.3^{AB} (±0.52)	5.2^{BC} (±0.53)	3.6^{B} (±0.40)	7.3^{AB} (±0.34)	6.6^{AB} (±0.31)	6.5^{BC} (±0.27)	5.5^{B} (±0.24)
Doughnuts	7.5^{AB} (±0.22)	7.3^{AB} (±0.15)	7.0^{DC} (±0.26)	-	7.5^{D} (±0.22)	7.2^{A} (±0.20)	6.5^{D} (±0.17)	-	7.5^{AB} (±0.27)	7.0^{AB} (±0.15)	6.4^{A} (±0.22)	-	7.0^{BC} (±0.42)	6.3^{A} (±0.39)	3.8^{B} (±0.42)	-	7.0^{AB} (±0.26)	6.8^{A} (±0.20)	4.6^{C} (±0.40)	-	7.3^{AB} (±0.23)	6.9^{AB} (±0.15)	5.7^{D} (±0.19)	-
C.D. ($P \leq 0.05$)	0.69	0.66	0.53	0.60	0.75	0.72	0.52	0.55	0.89	1.08	0.64	0.90	0.82	0.91	1.03	1.07	0.96	0.92	1.06	1.11	0.70	0.66	0.53	0.64

Value are mean ± S.E.
Superscripts with different letters differs significantly.
- Denotes not studied.

Browning

The data in Table 4.6 reveal that the browning, optical density (OD) at 440 nm increased significantly when compared with 0 day. The percentage increase of the browning during storage period, varied from 8.77 to 78.81 per cent. The maximum OD 0.039 ± 0.0004 was observed in namkeen para followed by biscuit (0.037 ± 0.0009), nutritious ladoo (0.037 ± 0.0003), nankhatai (0.026 ± 0.0004) and sweet and salty biscuit (0.021± 0.003) on 45th day . The increase in OD may be due to millard reaction and oxidation of phenolic compounds in the products.

Peroxide value

The primary products of lipid oxidation are hydroperoxides which are generally present as peroxides. Thus, it seems reasonable to determine the concentration of peroxide as a measure of extent of oxidaton and thus of rancidity. Peroxide values were therefore determined in fresh as well as stored samples.

The peroxide value of fresh samples ranged from 2.4 to 2.9 meq/kg sample while in stored mixtures it varied from 3.03 to 4.43 meq/kg (Table 4.7).

Perusal of data reveal that there were significant ($P<0.05$) differences among the mean peroxide value of the products. Stored products have higher peroxide value than that of fresh products. This may be due to increase in moisture content. During storage there was marked significant increase (57.14 to 68.03%) found on 45th day of storage. Dahiya and Kapoor (1994) also reported a gradual increase in peroxide value of bajra flour

Table 4.6. Effect of storage on non-enzymatic browning intensity of products based on crude palm oil

Name of the product	Browning intensity (Number of days)			
	0	15	30	45
Biscuit	0.021^{D} (±0.0006)	0.028^{C} (±0.0003) (32.70)	0.031^{C} (±0.0004) (48.32)	0.037^{B} (±0.0009) (76.77)
Nankhatai	0.015^{E} (±0.00065)	0.0186^{D} (±0.0003) (19.03)	0.021^{D} (±0.0003) (33.61)	0.026^{C} (±0.0004) (56.72)
Nutritious *ladoo*	0.022^{D} (±0.0007)	0.028^{C} (±0.0004) (19.03)	0.032^{C} (±0.0001) (33.61)	0.037^{B} (±0.003) (56.72)
Besan burfi	0.018^{D} (±0.0007)	-	-	-
Suji ladoo	0.008^{G} (±0.0002)	0.015^{F} (±0.0003) (72.09)	0.018^{E} (±0.0003) (116.27)	-
Cake	0.015^{E} (±0.0009)	-	-	-
Sweet and salty biscuit	0.012^{F} (±0.0003)	0.016^{E} (±0.0005) (35.59)	0.018^{E} (±0.003) (56.77)	0.021^{D} (±0.0003) (78.81)
Namkeen para	0.027^{A} (±0.0009)	0.034^{A} (±0.0005) (24.72)	0.037^{A} (±0.0003) (34.54)	0.039^{A} (±0.0004) (45.55)
Doughnuts	0.028^{A} (±0.0004)	0.031^{B} (±0.0003) (8.77)	0.035 (±0.0002) (22.80)	-
CD ($P \leq 0.05$)	0.00167	0.00123	0.00098	0.00120

Values are mean ± S.E.
Superscripts with different letters differs significantly.
Figures in parentheses indicate per cent increase as compared to initial value.
'-' Not studied

Table 4.7. Effect of storage on peroxide value of products based on crude palm oil

Name of the Product	Peroxide value (Meq/kg) (Number of days)			
	0	15	30	45
Biscuit	2.40^{D} (±0.00)	3.22^{D} (±0.05) (34.02)	3.60^{D} (±0.00) (50.00)	3.80^{C} (±0.00) (58.33)
Nankhatai	2.43^{D} (±0.03)	3.36^{C} (±0.04) (38.35)	3.63^{DC} (±0.03) (49.31)	3.96^{B} (±0.03) (63.01)
Nutritious *ladoo*	2.80^{C} (±0.00)	3.76^{B} (±0.02) (34.52)	4.20^{B} (±0.00) (50.00)	4.40^{A} (±0.00) (57.14)
Besan burfi	2.80^{C} (±0.00)	-	-	-
Suji ladoo	2.80^{C} (±0.00)	3.85^{B} (±0.03) (37.50)	4.16^{B} (±0.03) (48.80)	-
Cake	3.20^{A} (±0.00)	-	-	-
Sweet and salty biscuit	2.40^{D} (±0.00)	3.05^{E} (±0.07) (27.08)	3.70^{C} (±0.04) (54.16)	4.03^{B} (±0.03) (68.04)
Namkeen para	2.40^{D} (±0.00)	3.03^{E} (±0.08) (26.38)	3.46^{E} (±0.04) (44.44)	3.83^{C} (±0.03) (59.72)
Doughnuts	2.90^{B} (±0.00)	4.16^{A} (±0.03) (43.67)	4.43^{A} (±0.03) (52.87)	-
CD ($P \leq 0.05$)	0.0317	0.147	0.091	0.0751

Values are mean ± S.E.
Superscripts with different letters differs significantly.
Figures in parentheses indicate per cent increase as compared to initial value.
'-' Not studied

during 20 days storage.Dahiya(1991) Sehgal (1987)also reported the same trend in supplementary and weaning foods.

Fat acidity

The changes in lipid during storage were followed by determining fat acidity value. The fat acidity of the fresh products ranged from 86.16 to 43.00 mg KOH/100 g of the products. While in stored products it varied from 48.66 to 98.0 mg KOH/100 g (Table.4.8). There were significant ($P<0.05$) differences between fat acidity values of all the fresh products. All the products stored for different days showed gradual significant increase in the fat acidity value. There was 13.73 to 31.57 per cent icnrease in fat acidity on 45th day of storage. With the addition of crude palm oil along with fat, the fat acidity of the products increased in all types of preparations. It was osberved that the percentage of fat acidity from 0 day to 15 day was low i.e. 4.25 to 16.54per cent. Whereas on 30th day the fat acidity values are significantly higher and the increase in fat acidity over 0 day was ranged between 11.79 to 28.47 per cent. The similar significant increase was also found in the stored products of 45th day. The per cent fat acidity values ranged from 13.73 to 31.57 on 45th day. Dahiya(1991) Gupta (1989) and Sehgal (1987) also found an increase in fat acidity of the developed supplementary foods.

Free fatty acids

The free fatty acid content of fresh supplements ranged from 0.28 to 0.72 per cent,while in stored supplements,it varied from 0.42 to 1.24 per cent (Table 4.9).

Table 4.8. Effect of storage on fat acidity of products based on crude palm oil

Name of the product	Fat acidity (mg KoH / 100 g) (Number of days)			
	0	15	30	45
Biscuit	79.17^{C} (±0.17)	83.00^{B} (±0.26) (4.84)	90.33^{B} (±0.42) (14.10)	96.67^{B} (±0.42) (22.10)
Nankhatai	86.17^{B} (±0.17)	89.83^{A} (±0.40) (4.25)	96.33^{A} (±0.33) (11.79)	98.00^{A} (±0.00) (13.73)
Nutritious *ladoo*	64.50^{D} (±0.34)	68.17^{C} (±0.17) (5.68)	75.83^{C} (±0.17) (17.67)	82.17^{C} (±0.17) (27.39)
Besan burfi	76.33^{A} (±0.84)	-	-	-
Suji ladoo	59.50^{F} (±0.22)	64.83^{D} (±0.17) (8.96)	73.33^{D} (±0.42) (23.24)	-
Cake	61.17^{E} (±0.17)	-	-	-
Sweet and salty biscuit	43.00^{I} (±0.63)	48.67^{F} (±0.33) (13.17)	53.83^{G} (±0.17) (25.19)	55.67^{E} (±0.33) (29.45)
Namkeen para	44.33^{H} (±0.21)	51.67^{E} (±0.42) (16.54)	56.33^{F} (±0.61) (27.06)	58.33^{D} (±0.33) (31.57)
Doughnuts	48.00^{G} (±0.26)	51.67^{E} (±0.33) (7.63)	61.67^{E} (±0.42) (28.47)	-
CD (P≤0.05)	1.152	0.897	1.126	0.851

Values are mean ± S.E.
Superscripts with different letters differs significantly.
Figures in parentheses indicate per cent increase as compared to initial value.
'-' Not studied

Table 4.9. Effect of storage on free fatty acids of products based on crude palm oil

Name of the product	Free fatty acids (%) (Number of days)			
	0	15	30	45
Biscuit	0.56^{B} (±0.00)	0.82^{C} (±0.02) (45.83)	0.99^{B} (±0.00) (75.00)	1.10^{B} (±0.02) (25.83)
Nankhatai	0.73^{A} (±0.0.02)	0.99^{A} (±0.00) (35.45)	1.10^{A} (±0.02) (51.61)	1.24^{A} (±0.00) (70.62)
Nutritious *ladoo*	0.73^{A} (±0.02)	0.87^{B} (±0.02) (19.35)	0.96^{B} (±0.02) (32.25)	1.13^{B} (±0.00) (54.83)
Besan burfi	0.71^{A} (±0.00)	-	-	-
Suji ladoo	0.42^{C} (±0.00)	0.73^{D} (±0.02) (72.22)	0.85^{C} (±0.00) (100.00)	-
Cake	0.42^{C} (±0.00)	-	-	-
Sweet and salty biscuit	0.44^{C} (±0.01)	0.56^{E} (±0.00) (29.65)	0.68^{D} (±0.02) (56.66)	0.85^{C} (±0.00) (94.48)
Namkeen para	0.28^{D} (±0.00)	0.42^{F} (±0.00) (50.00)	0.56^{F} (±0.00) (100.00)	0.71^{D} (±0.00) (150.00)
Doughnuts	0.56^{B} (±0.00)	0.85^{CB} (±0.00) (50.00)	0.98^{B} (±0.00) (75.00)	-
CD ($P \leq 0.05$)	0.336	0.442	0.044	0.306

Values are mean ± S.E.
Superscripts with different letters differs significantly.
Figures in parentheses indicate per cent increase as compared to initial value.
'-' Not studied

Perusal of data reveal that there were significant ($P<0.05$) differences among free fatty acid content of the f resh-products. But products like nankhatai, nutritious ladoo, besan burfi and cake, sweet and salty biscuits showed nonsignificant ($P<0.05$) difference in free fatty acid content. On 15th day the free fatty acid content increased significantly ($P<0.05$) from fresh products and they ranged between 0.42 to 0.98 per cent. The percentage increase was also significantly higher and ranged between 19.35 to 50 per cent. When the free fatty acid content of the stored products were observed they increased significantly and the percentage increase in free fatty acid content ranged between 19.35 to 150 per cent. Dahiya (1991) Sehgal (1987) also reported the same trend in supplementary and weaning foods.

β-carotene

β-carotene content of all the dehydrated vegetables decreased significantly ($P<0.05$) with increase in storage period (Table 4.10). On comparing loss in β-carotene after 45 days of storage there was a significant loss i.e. 14.83 per cent in biscuit, 12.21 per cent in nankhatai, 14.93 per cent in nutritious ladoo, 20.77 per cent in namkeen para and a maximum loss was osberved in sweet and salty biscuits i.e. 30.73 per cent. The observed reduction in β-carotene during storage might be due to oxidative and/or non-oxidative changes as it is heat sensitive (Patil *et al.*, 1978). Reduction in β-carotene in dehydrated fenugreek on storage has been reported by Patil *et al.* (1978). Mehta and Tomar (1980) and Ranganath and Dubash (1981) also observed losses in β-carotene in dried papaya pieces and spinach during one year and four months of storage. Anita (1997) found

Table 4.10. Effect of storage on β-carotene of products based on crude palm oil

Name of the product	β-carotene (μg/g) (Number of days)			
	0	15	30	45
Biscuit	38.85^{B} (±0.17)	36.15^{B} (±0.13) (-4.47)	34.21^{B} (±0.12) (-9.60)	32.23^{B} (±0.22) (-14.83)
Nankhatai	43.64^{A} (±0.0.15)	42.33^{A} (±0.16) (-3.02)	40.84^{A} (±0.19) (-6.42)	38.31^{A} (±0.12) (-12.21)
Nutritious *ladoo*	37.88^{B} (±0.12)	35.71^{B} (±0.17) (-5.75)	34.54^{B} (±0.37) (-8.82)	32.23^{B} (±0.26) (-14.93)
Besan burfi	27.50^{E} (±0.17)	-	-	-
Suji ladoo	23.85^{F} (±0.10)	21.65^{D} (±0.23) (-9.25)	20.05^{D} (±0.12) (-15.95)	-
Cake	33.24^{C} (±0.31)	-	-	-
Sweet and salty biscuit	20.95^{H} (±0.05)	18.73^{F} (±0.15) (-10.59)	16.64^{F} (±0.22) (-20.55)	14.51^{D} (±0.18) (-30.73)
Namkeen para	28.05^{D} (±0.06)	26.13^{C} (±0.11) (-6.87)	24.15^{C} (±0.03) (-13.91)	22.23^{C} (±0.19) (-20.77)
Doughnuts	21.42^{G} (±0.12)	19.47^{E} (±0.15) (-9.105)	17.53^{E} (±0.10) (-18.15)	-
CD (P≤0.05)	0.451	0.461	0.559	0.516

Values are mean ± S.E.
Superscripts with different letters differs significantly.
Figures in parentheses indicate per cent increase as compared to initial value.
'-' Not studied

10.51 per cent decrease in β-carotene after two months of storage . Vashista (1998) also reported decrease in β-carotene content of tomato soup powder dring storage for two months. Geetu (1999) also reported similar scenario in dried Amaranthus leaves.

Total carotenoids

Total carotenoids content of all the fresh and stored products decreased significantly ($P<0.05$) with increase in storage period (Table 4.11). On comparing loss in total carotenoids after 45 days of storage there was a significant loss 17.77 per cent in sweet and salty biscuit 15.50 per cent in namkeen para, 10.72 per cent in biscuit 10.31 per cent in nutritious ladoo and 6.71 per cent in nankhatai. Maximum retention of total carotenoids was observed in nutritious ladoo where the retention of total carotenoids was 93.3 per cent. It may be due to less boiling time of crude palm oil taken in the preparation of nutritious ladoo. The observed decline in total carotenoids may be due to oxidative/or non-oxidative changes as it is heat sensitive (Patil *et al.*, 1978).

4.5 Assessment of nutritional status of subjects

4.5.1 Back ground profile of the respondents selected for supplementation trial

Most of the respondents (40.00%) were in 7 years age group and 36.66 per cent means 11 respondents were in 9 years of age group. Rest of the respondents 7 (23.33%) were belonged to 8 years of age group. Most of the respondents (53.33%) were female i.e. 16. The rest of the respondents were males i.e. 14 respondents.

Table 4.11. Effect of storage on total cartenoids of products based on crude palm oil

Name of the product	Total carotinoids (µg/g) (Number of days)			
	0	15	30	45
Biscuit	56.86^{B} (±0.18)	54.62^{B} (±0.22) (-3.95)	52.84^{B} (±0.22) (-7.07)	50.76^{B} (±0.22) (-10.72)
Nankhatai	64.11^{A} (±0.0.19)	62.60^{A} (±0.17) (-2.35)	61.96^{A} (±0.20) (-3.35)	59.81^{A} (±0.16) (-6.71)
Nutritious *ladoo*	55.59^{C} (±0.32)	53.89^{C} (±0.46) (-3.05)	52./09^{C} (±0.36) (-6.29)	49.86^{C} (±0.44) (-10.31)
Besan burfi	40.10^{E} (±0.30)	-	-	-
Suji ladoo	34.48^{F} (±0.18)	32.27^{E} (±0.30) (-6.340	30.45^{F} (±0.23) (-11.69)	-
Cake	30.91^{H} (±0.12)	-	-	-
Sweet and salty biscuit	30.50^{H} (±0.03)	28.51^{G} (±0.06) (-6.50)	26.39^{G} (±0.11) (-13.46)	25.75^{E} (±0.21) (-17.77)
Namkeen para	41.46^{D} (±0.04)	39.50^{D} (±0.12) (-4.73)	37.17^{D} (±0.04) (-10.34)	35.11^{D} (±0.05) (-15.31)
Doughnuts	31.63^{G} (±0.10)	29.36^{I} (±0.14) (-7.14)	27.35^{F} (±0.11) (-13.45)	-
CD (P≤0.05)	0.540	0.702	0.606	0.724

Values are mean ± S.E.
Superscripts with different letters differs significantly.
Figures in parentheses indicate per cent increase as compared to initial value.
'-' Not studied

As the respondents were belonging to low socio-economic status their family income was very low. It ranged between Rs. 1500-3000. Most of the respondents belonged to Rs. 2100-2500 range. About 46.66 per cent of the respondents family consisted of 6-7 members (Table 4.12).

Due to industrialization,the trend joint families system are were decreasing drastically and nuclear families are emerging. So,in the present study the most of the respondents (53.33) also belonged to nuclear families.

4.5.2 Dietary assessment

4.5.2.1 Food consumption pattern of school children

Cereals

Mean daily intake of cereals of boys was 205.92 ± 8.12 g which was 82.36 per cent and RDI (Table 4.13). Girls had a lower intake of cereals (73.72% of RDI). Among cereals, wheat was the staple food in their diet. Along with this rice was also being consumed frequently. Gill *et al.* (1968) reported that main food eaten by rural school children were jowar, rice and wheat. Verma and Bajaj (1985) reported that cereal consumption was only 59-64 per cent of RDI, in girls belonging to different income groups. On the contrary, Singh (1979) reported that cereals were consumed near or above the RDI. Pushpamma *et al.* (1983) in a study reported food intake to be deficient in all food groups except cereals. Kaur and Sharma (1986) and Sarupriya and Mathew (1988) reported adequate of cereals by school children.

Pulses

The main intake of pulses in boys and girls was 33.00 ± 2.27 g and

Table 4.12. Background profile of the respondents selected for supplementation trial

General information		Group I (n=10)	Group II (n=10)	Group III (n=10)	Total (N=30)
Age	7 yrs	4	3	5	12 (40.00)
	8 yrs	1	2	4	07 (23.33)
	9 yrs	5	5	1	11 (36.66)
Sex	Male	3	6	5	14 (46.66)
	Female	7	4	5	16 (53.33)
No of family members	4-5	3	3	4	10 (33.33)
	6-7	5	4	5	14 (46.66)
	8-9	2	3	1	06 (20.00)
Income of the family (Rs.)	1500-2000	3	2	0	05 (16.66)
	2100-2500	6	6	9	21 (70.00)
	2600-3000	1	2	1	04 (13.33)
Type of family	Nuclear	4	6	6	16 (53.33)
	Joint	6	4	4	14 (46.66)

Table 4.13. Mean daily food intake of school chidlren (7-9 years)

Food stuffs	RDI (g)	Mean intake (g) per day			% RDI	
		Boys (n=14)	Girls (n=16)	t-value	Boys	Girls
Cereals	250	205.92 (±8.12)	184.31 (±7.98)	10.59*	82.36	73.72
Pulses	70	33.00 (±2.27)	28.68 (±1.03)	4.68*	47.14	40.97
Vegetables	152	40.92 (±3.14)	39.50 (±1.74)	1.25^{NS}	32.73	31.60
Fruits	50	24.42 (±2.71)	21.50 (±2.39)	2.53*	48.84	43.00
Milk and milk products	250	69.57 (±1.69)	70.50 (±2.66)	0.88^{NS}	27.82	28.20
Fat and oils	30	8.05 (±0.77)	8.23 (±0.58)	0.30^{NS}	26.83	27.43
Sugar and jaggery	50	18.50 (±1.39)	19.62 (±1.09)	1.396^{NS}	37.00	39.24

Value are mean ±S.E.
RDI = Recommended dietary intake
*Significant at ($P<0.05$)
NS = Non-significant

28.68 ± 1.03 g, respectively which was lower than RDI in both (Table 4.13). There were less differences in the intake by girls and boys.

The pulses commonly consumed by them were moong, arhar and channa dhal. Consumption of moong dhal was more as compared to other pulses. Singh (1979) also reported that school children consumed pulses below RDI. Similarly, Pushpamma *et al.* (1983) also found the diets of rural school children to be deficient in pulses. Verma and Bajaj (1985) reported consumption of pulses to be only 37-60 per cent of RDI. In contrast, Mann *et al.* (1991) reported that consumption of pusles was higher than RDI in Punjab.

Vegetables

Intake of vegetables in boys and girls was 40.92 ± 3.14 g and 39.50 ± 1.74 g, respectively (Table 4.13). When compared sex-wise, the intake of boys was slightly higher than girls though it was much below RDI. Among roots and tubers, carrot, raddish, potato and onions were more consumed. Among other vegetables, bottleguard, brinjal, tomato, green chillies, lady finger, pumpkin, peas and ridge gourd were commonly consumed. Consumption of potatoes, peas and bottle gourd was maximum. Spinach and sarson were common among green leafy vegetables. Less consumption of vegetables by these children may be due to the reason that mothers were not much aware about the importance of vegetables in diet. Similarly, less intake of vegetables has been reported by Ishigaki (1979) and Bozza *et al.* (1980). Pushpamma *et al.* (1983) reported that the diets of 90 per cent of rural families did not include vegetables in their diets. Similar, work done

by Pant and Solanki (1989) reported negligible consumption of green vegetables in school boys.

Fruits

Mean intake of fruits was 24.42 ± 2.71 g per day in boys which was nearly fifty per cent (48.84%) of RDI. In girls it was 21.50 ± 2.39 g per day (43.00% of RDI) (Table 4.13). Fruits mainly consumed were ber and banana. Lack of awareness about the importance of fruits in diets and low purchasing power may be the main reasons, contributing to low intake of fruits. Similarly, several research workers have reported low intake of fruits by school children (Singh,1979; Pushpamma *et al.*, 1983). On the contrary, Rolle and Gram (1987) found that diets of children contained plenty of fruits.

Milk and Milk Products

The daily mean intake of milk and milk products was 69.57 ± 1.69 g (27.82% of RDI) in boys. In girls, it was 70.50 ± 2.66 g per day (28.2% of RDI) (Table 4.13). it seems that girls consumes more milk than boys. Goat milk consumption was more as compared to cow or buffalo milk. In a study Martinez (1982) reported less consumption of milk by girls as compared to boys. Pushpamma *et al.* (1983) reproted that diets of rural shcool children were deficient in milk and milk products. On the contrary, Gill *et al.* (1968), Singh (1979) and Rolle and Gram (1987) reported that consumption of milk was high among children and it was at par or above RDI.

Fats and Oils

Table 4.13 depicts that daily mean consumption of fat and oil in both

boys and girls was very low. Boys consumed 8.05 ± 0.77 g of fat per day which was only 26.83 per cent of RDI. Intake of girls was also low i.e. 8.23 ± 0.58 per day (27.43% of RDI). Low purchasing power may be the contributing factor for low intake. Singh (1979) and Pushpamma *et al.* (1983) reported that fats and oils consumed were below the RDI by the children.

Sugar and Jaggery

Mean intake of sugar and jaggery observed was 18.50 ± 1.39 g (37% of RDI) in boys and 19.62 ± 1.09 (39.24% of RDI) in girls. Intake was more in the form of jaggery rather than sugar (Table.4.13). Similarly, Pushpamma *et al.* (1983) reported that diets of school children were deficient in sugar and jaggery. On the contrary, Singh (1979) reported that sugar intake to be more than double the RDI. Rolle and Gram (1987) also reported that sugar consumption was usually in excess amount and also was double the RDI.

4.5.2.2 Nutrient intake of school children

The overall means of daily nurient intakes of children (7 to 9 years old) of Government school are given in Table 4.14.

Energy

The energy intake of all the children was significantly ($P<0.05$) lower than RDA. Daily intake of energy in boys ranged from 787.45 Kcal to 1045.48 Kcal with a mean intake of 898.62 ± 125.92 Kcal which was only 46.08 per cent of RDA. Intake of energy in girls was only 43.83 per cent of RDA. Their daily intake ranged from 697.54 Kcal to 985.63 Kcal with a mean intake of 854.87 Kcal (Table 4.14).

Table 4.14 Mean daily nutrient intake of school children of 7-9 years (Boys and girls)

Nutrient	RDA	Mean intake per day		t-value Intake Vs RDA		t-value
		Boys (n=14)	Girls (n=16)	Boys	Girls	Boys-Girls
Energy (Kcal/day)	1950	898.62 (±125.92) (46.08)	854.87 (±134.44) (43.83)	31.23*	32.59*	10.49*
Protein (g/day)	41	24.93 (±6.23) (60.80)	23.10 (±4.78) (56.31)	9.65*	14.98*	2.13*
Fat (g/day)	25	10.83 (±2.95) (43.28)	11.06 (±2.36) (44.20)	17.99*	23.64*	0.38^{NS}
Vitamin (A) (µg/dl)	2400	1140.47 (±212.15) (47.51)	1179.65 (±250.98) (49.15)	22.19*	19.44*	7.05*

Values are mean±SD.
*Significant at ($P<0.05$)
RDA = Recommended dietary allowances of ICMR (1991)
Figures in parentheses indicate per cent RDA.

While comparing the energy intake of girls and boys, the difference in intake was found to be significant. This difference may be due to consumption of more food stuffs especially chapatis and milk by boys than girls.

Sankhla (1987) studied nutritional status of urban and tribal school children of Udaipur city and found the diets of children to be deficient in calories. Goyal (1994) studied the nutritional status of school going children (7-9 years old) in rural area sof Rohtak district and reported that their intakes were lower than RDAs. Similarly, Mo *et al.* (1990), Mann *et al.* (1991), Chandna (1993) and Soltysova and Bellisle (1994), Sangeeta (1995) reported low intakes of energy in school children.

In contrast, Thimmayamma *et al.* (1982) in a dietary survey of school children in Andhra Pradesh found that 70 to 100 per cent of the subjects of upper middle income group had adequate energy intake. Also Sridharan *et al.* (1984) and Doyle *et al.* (1994) reported, energy intakes of school children were more or less adequate.

Protein

Daily intake of protein by boys ranged from 20.36 g to 30.86 g with an average intake of 24.94 g which was 60.80 per cent of RDA. Mean protein intake in girls was also lower than RDA i.e. 23.10 g which formed 56.31 per cent of RDA. It ranged from 19.76 g to 29.45 g. The difference in protein intake of boys and girls was not found to be significant (Table 4.14).

The observed lower protein intake may be due to the reason that diets of these children were deficient in protein rich foods (Pulses, meat, egg, milk, etc.). This may be due to their low socio-economic status and lack of awareness or disliking for the particular protein rich food.

Gibson *et al.* (1991) in his study of children (six to ten years old) found that 73 per cent had protein intakes less than FAO/WHO/UNO recommendations. Chandna (1993) while studying school children (six to nine years old) found their daily mean intakes of proteins to be significantly lower than RDA. It was found that the protein intake of school going children (7 to 9 years old) was lower than RDA by Sankhla (1987), Moreiras Varela *et al.* (1988), Goyal (1994) and Sangeeta (1995).

In contrast, Mann *et al.* (1991) studied the meal pattern of boys and girls (5 to 10 years old) from middle class families in Ludhiana and found that diets were high in protein. Similarly, Verma (1983), Bai *et al.* (1984) and Carabini *et al.* (1992) reported adequate intakes of protein in school children. Verma and Bajaj (1986)also found the protein intake to be 124-133 per cent of RDA in girls belonging to different income groups.

Fat

The daily mean intake of fat in boys varied from 7.45 g to 15.42 g with mean intake of 10.83 g (43.28% of RDA). Mean intake of girls was 11.06 g (44.20% of RDA) and it varied from 5.45 g to 13.83 g. The comparison of intake in boys and girls showed that though both the diets did not meet dietary requirements of children, the amount of the fat consumed by both boys and girls was statistically non-significant. The less

consumption of visible fat and fried foods may be the reason contributing to low amount of fat in the diet (Table.4.14).

Goyal (1994) investigated the nutritional status of school children (7 to 9 years old) and found the mean fat intake to be lower than RDA. Similarly, Chandna (1993) and Sangeeta (1995) also reported lower consumption of fat in school children.

In contrast McNeil *et al.* (1991) reported excess intake of fat in diets of children. Rolle and Grams (1987) calculated dietary intake of school children in Copenhagen and found that suplies of fat were usually excessive in diets.

Vitamin A

Average vitamin A intake by boys and girls was reported to be 1140.47 µg/dl (47.51% of RDA) and 1179.65 µg/dl (49.15% of RDA), respectively (Table 4.14) . The less consumption of vitamin A is due to lack of awareness and disliking of green leafy vegetables by school going children. Susheela and Sehgal(1994), Goyal (1994) in a study carried out on school going children revealed dietary intake of vitamin A and vitamin A rich foods was much below RDA.

4.5.3 Anthropometric and biochemical assessment

Anthropometric measurements of the children from Govt. School, Hisar were taken during the preliminary survey and compared to standard reference values. The overall means of the various measurements taken for boys and girls are given in Table 4.15.

Table 4.15. Anthropometric measurements of school children (7-9 years)

(N=30)

Anthropometric parameter	Boys (n=14)			Girls (n=16)		
	Reference value	Observed value	% Reference value	Reference value	Observed value	% Reference value
Weight (kg)	24.25[a]	18.91 (±1.78)	77.97	23.65[a]	18.85 (±2.23)	79.70
Height (cm)	124.25[a]	116.58 (±6.13)	93.82	123.45[a]	108.64 (±6.01)	88.00
Serum retinol (µg/dl)	25-90[b]	17.00 (±9.02)	68.00	25-90[b]	14.55 (±2.94)	58.20

Values are mean±SD

[a]Indian Council for Medical Research (ICMR) 1989.

[b]Swaminathan (1999)

Weight

Mean weights of the school children were lower than ICMR reference values. Mean weight of the boys was 18.91 ± 1.78 kg which was 77.97 per cent of the reference value. Mean weight of the girls (18.85 ± 2.23 kg) was 79.70 per cent of reference value (Table 4.15). Pai and Naik (1989) observed that weight of rural children (6.5 to 10.5 years) in Karnataka were significantly lower than the standards of ICMR. Joshi *et al.* (1993), Goyal (1994) and Sangeeta (1995) also reported that Indian rural school children weighed very less than ICMR standards.

Observed mean weight of boys in our study was slightly higher than that of girls. A similar study by Easwaran *et al.* (1972) showed that mean weight of boys was greater than that of girls. Kumar *et al.*(1990) also observed that boys were heavier than girls till nine years of age. In contrast, Pai and Naik (1989) suggested that girls weighed more than boys.

Height

Mean height of boys was 116.58 ± 6.13 cm which was 93.82 per cnet of reference value whereas in girls, the mean height observed was 108.64 ± 6.01 cm which was 88.00 per cent of reference value (Table 4.15). Goyal (1994), Sangeeta (1995) have observed that mean height of boys (7 to 9 years old) was 93.2 ± 89.29 per cent of reference value respectively and that of girls was 92.1 and 90.34 per cent of reference value. Similarly, Rao *et al.* (1984), Bai *et al.* (1979), Verma and Bajaj (1985) and Chandna (1993) reported heights of schol children to be lower than standards.

Serum retinol

The observed mean value of serum retinol in boys was 17.00 ± 9.02 µg/dl which was only 68.00 per cent of the minimum normal value. Girls had a still lower value (14.55 ± 2.94 µg/dl) which was 58.20 per cent of minimum normal value (Table 4.15).

The low serum retinol levels was mainly due to low purchasing power and also due to lack of awareness about the richest sources of vitamin A.

Similarly, Susheela (1969) and Srikantia and Reddy (1970) had conducted a study on school going children and found that the serum retinol levels were much below the minimum normal serum levels i.e. 25 µg/dl.

4.5.4 Clinical assessment

All the children were examined for the presence of various deficiency signs and symptoms with the help of a medical practitioner. It was found that 23.33 per cent (7 students) respondents had night blindness (Table 4.16). It was also found that 10.00 per cent of the respondents (3 students) had bitot's spots.

Prevalence of various deficiency symptoms among school children has also been reported by Rao (1987), Pant and Solanki (1987), Goyal (1994) and Sangeeta (1995).

4.6 Feeding trials and its impact on nutritional status

4.6.1 Selection of supplements and subjects for feeding

Out of twelve supplements developed, three supplements were selected for feeding on their nutritive value, shelf life, ease in preparation

Table 4.16. Presence of deficiency signs among school children

	Group I (n=10)	Group II (n=10)	Group III (n=10)	Total (n=30)
Night blindness	2	2	3	7 (23.33)
Bitot's spots	1	1	1	3 (10.00)
Conjunctival xerosis	-	-	-	-
Corneal xerosis	-	-	-	-
Kerato malacia	-	-	-	-

Group I - Control group
Group II - Prophylactic group
Group III - Feeding trial group

and organoleptic scores. The three selected supplements were biscuit, nankhatai and nutritious ladoo (Table 4.17).

The amount of each of the supplements to be fed was so calculated that they provided 5 gram crude palm oil per serving in order to provide more than half of recommended dietary allowances of 7-9 years old children i.e. 1323 μg of β-carotene day. Amount fed for biscuit was 36.0 g, for nankhatai 31.00 g and 36.00 g of nutritious ladoo.

The β-carotene cotnent of the supplements fed varied from 1347.10 μg/g to 1363.75 μg/g being lowest for biscuit and highest for nankhatai (Table 4.17).

4.6.2 Impact of suppelemntary feeding on nutritional stauts

The outcome of the nutritional feeding was evaluated from records of height, weight and other anthropometric measurements recorded before and after the experimental period of one month. Records of serum retinol levels, nutrient intake were also maintained and used as criteria for evaluation of the impact of the diets.

4.6.2.1 Impact on nutrient intake

Energy

Mean energy intake through diet before supplementation was 864.76 K.cal/day and with supplementation I i.e. biscuit the energy intake was increased to 1061.51 Kcal/day (Table 4.18). Per cent RDA for this supplement was increased from 44.34 per cent to 54.45 per cent. With supplement II the per cent RDA was increased from 44.34 to 53.10 per cent. Mean intake through this supplement was icnreased to 1035.49 Kcal/

Table 4.17. Nutritive value of developed supplements selected for feeding

Recipe	Amount fed (g)	Protein (g)	Energy (K.cal)	β-carotene (μg)
Biscuit	36.00	3.05	196.75	1347.10
Nankhatai	31.00	3.06	170.73	1363.75
Nutritious *ladoo*	36.00	3.80	230.19	1363.68

Table 4.18. Effect of feeding developed supplements on nutrient intake of school children

Nutrient	RDA	Mean daily intake through diet	Total intake with supplement I (Biscuit 36 g)	Total intake with supplement II (*Nankhatai* 31 g)	Total intake with supplement III (Nutritious *ladoo* 36 g)
Energy (K.cal/day)	1950	864.76 (44.34)	1061.51 (54.45)	1035.49 (53.10)	1094.95 (56.15)
Fat (g/day)	25	10.95 (43.80)	22.22 (88.88)	22.96 (91.84)	18.60 (74.40)
Protein (g/day)	41	23.95 (58.41)	27.00 (65.85)	26.69 (65.12)	27.75 (67.68)
Vitamin A (µg/day)	2400	1141.83 (47.57)	2453.33 (102.22)	2457.65 (102.40)	2361.51 (98.39)

Figures in parentheses indicate NAR (Per cent RDA)

day. Mean energy intake was increased to 1094.95 Kcal/day i.e. 44.34 per cent to 56.15 per cent of RDA.

Fat

Total fat intake was increased from 43.8 per cent to 88.88 per cent of RDA with supplement I i.e. 10.95 g/day to 22.22 g/day. With supplement II the total intake of fat was increased from 10.95 g/day to 22.96 g/day. With supplement III i.e. nutritious ladoo the per cent intake was increased from 43.8 to 74.4 per cent of RDA.

Maximum increase in fat intake was observed through nankhatai i.e. 91.84 per cent of RDA from 43.8 per cent of actual intake (Table 4.18).

Protein

Mean intake of protein through diet was 23.95 g/day and it was increased to 27.00 g/day with supplement I. The per cent RDA for this grop increased from 58.41 per cent to 65.85 per cent (Table 4.18). Per cent RDA for group II increased from 58.41 per cent to 65.12 per cent. Though supplement III the intake of protein was increased from 23.95 g/ day to 27.75 g/day. The per cent increase in RDA was from 58.41 to 67.68 per cent.

Vitamin A

The daily mean intake of vitamin A in terms of β-carotene was found to be 1141.83 µg/day. The intake of vitamin A through suplement I was increased to 2453.33 µg/day, supplement II was increased to 2457.65 µg/ day and through supplement III the intake was increased to 2361.51 µg/ day. The per cent RDA increased from 47.57 to 102.22, 102.40 and 98.39

per cent through biscuit, nankhatai and nutritious ladoo, respectively (Table.4.18).

Total vitamin A intake with supplements increased more than RDA through biscuit and nankhatai. Sangeeta (1995)also reported that the nutrient intake through supplementation trial was increased significantly.

4.6.2.2 Effect on anthropometric measurements

Studies on growth and physical development of children are important as they provide determinants of a nation's health. Measurements of height and weight are still the simplest and reliable means of evaluation of progress of a normal child and gross abnormalities, even when no other clinical signs of illness manifest.

4.6.2.2.1 Body weight

The initial body weights of two groups as well as the control groups were almost same (18.295 ± 0.334 to 19.225 ± 0.774 kg (Table 4.19). Mean increase in body weight after one month feeding was 2.17 ± 0.16, in supplemented group and was 1.66 ± 0.29 in prophylatic group, while in control group it was 1.27 ± 0.21. Maximum increase was obtained in supplement group (11.86%) in which mean body weight increased from (18.29 ± 0.334 to 20.477 ± 0.39). The mean weights increased by 8.68 per cent in prophylactic group and 6.60 per cent in control group.

The gain in body weight of children fed on different supplements did not differ significantly among themselves, however, the increase in case of supplemented groups was significantly ($P<0.05$) higher than that of control group.

Table 4.19. Effect of feeding developed supplements on body weight of school children

(N=30)

Supplement	n	Initial (kg)	Final (kg)	Increase	Source of variation	t-value
Group I	10	19.23 (±0.77)	20.50 (±0.77)	1.27±0.21 (6.60)	Initial Vs final Group I Vs Group II	5.99* 1.08^{NS}
Group II	10	19.12 (±0.72)	20.78 (±0.68)	1.66± 0.30 (8.68)	Initial Vsfinal Group II Vs Group II1	5.59* 1.51^{NS}
Group III	10	18.30 (±0.33)	20.47 (±0.39)	2.17±0.16 (11.86)	Initial Vs final Group I Vs Group III	13.48* 3.38*

*Significant ($P<0.05$)
NS - Non-significant
Values are mean±S.E.
Figures in parentheses indicate per cent increase in weight as compared to initial value

The increase in energy, protein and fat intake through these supplements can be accounted towards the gain in body weights. Non-significant differences in weight gain inchildren due to different supplements may be ascrfibed to almost same calorie, protein and fat of the supplements.

Kabir *et al.* (1994) showed that children fed high protein diet gained significantly more weight than those not receiving it. Gao (1991) found that feeding of supplements containing 80 per cent soyabean or groudnnut protein as well as other plant proteins and trace elements to primary school pupils resulted in significant gain in body weights.

Comparitive effects on boys and girls

Boys and girls did not differ significantly with respect to their gain in bodyw eight (Table 4.20). Girls of control group gained 1.29 kg as compared to the gain of 1.22 kg by boys. Prophylactic group girls gained 9.82 per cent while boys gained 8.01 per cent of their initial body weights. Gain in body weight of girls with supplements was 12.87 per cent (2.39 kg) as compared to 10.87 per cent (1.96 kg) in boys (Fig. 1).

4.6.2.2.2 Height

Mean increase in body height after one month feeding was 1.15 ± 0.13 kg in supplementation group and was 1.61 ± 0.16 kg in prophylactic group. It was 2.84 ± 0.34 kg in control group. Mean height increased by 2.42 per cent in control group, 1.61 per cent in prophylactic group and was 0.97 per cent in supplementation group (Table.4.21).

The increase in height of children fed on prophylactic dose and supplements differ significantly among themselves. The increase in supplementation group was not significantly higher than other two groups.

Table 4.20. Comparative effect of feeding developed supplements on body weight (kg) of girls and boys

(N=30)

Supplement	Girls					Boys				
	Ref. value	n	Initial	Final	Increase	Ref. value	n	Initial	Final	Increase
Group I	23.65[a]	7	19.41 (±1.05) (82.07)[c]	20.70 (±0.96) (87.52)[c]	1.29 (6.64)[b]	24.25*	3	18.78 (±1.03) (77.44)[c]	20.00 (±1.53) (82.47)[c]	1.22 (6.49)[b]
Group II		4	18.23 (±1.21) (77.04)[c]	20.01 (±0.81) (84.60)[c]	1.79 (9.82)[b]		6	19.72 (±0.89) (81.27)[c]	21.30 (±1.01) (87.79)[c]	1.58 (8.01)[b]
Group III		5	18.57 (±0.55) (78.52)[c]	20.96 (±0.44) (88.62)[c]	2.39 (12.87)[b]		5	18.02 (±0.40) (74.37)[c]	19.98 (±0.62) (82.39)[c]	1.96 (10.87)[b]

Values are mean±S.E.

[a] Indian Council of Medical Research (1989)

[b] Per cent increase as compared to initial value.

[c] Per cent increase as compared to reference value.

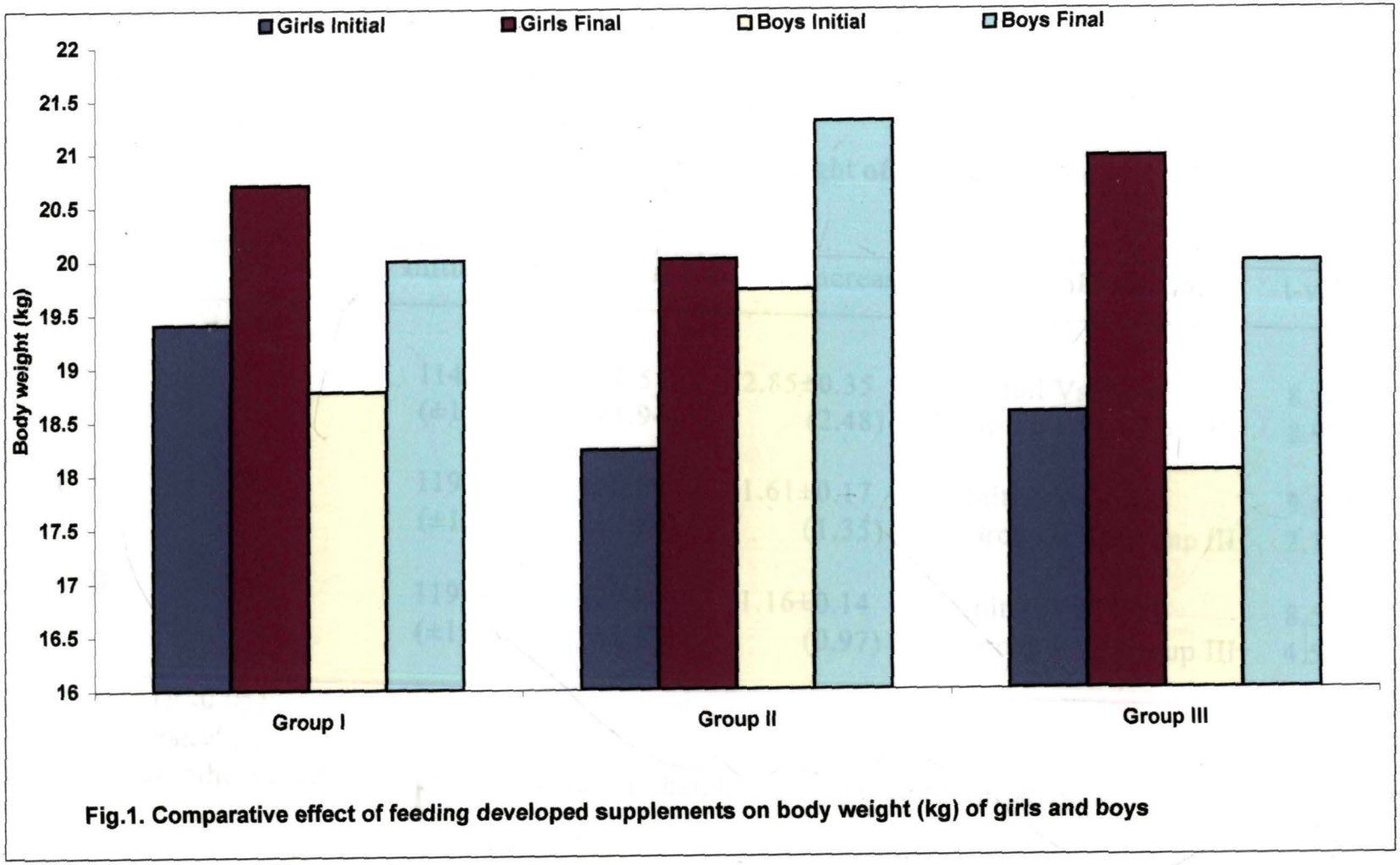


Fig.1. Comparative effect of feeding developed supplements on body weight (kg) of girls and boys

Table 4.21. Effect of feeding developed supplements on height of school children

(N=30)

Supplement	n	Initial (cm)	Final (cm)	Increase	Source of variation	t-value
Group I	10	114.68 (±1.19)	117.53 (±1.94)	2.85±0.35 (2.48)	Initial Vs Final Group I Vs Group II	8.16* 8.90*
Group II	10	119.33 (±1.89)	120.94 (±1.80)	1.61±0.17 (1.35)	Initial Vs Final Group II Vs Group III	9.81* 2.15*
Group III	10	119.04 (±1.38)	120.20 (±1.42)	1.16±0.14 (0.97)	Initial Vs Final Group I Vs Group III	8.5* 4.54*

*Significant ($P<0.05$)

Values are mean±S.E.

Figures in parentheses indicate per cent increase in height as compared to initial value

Height is also influenced by heredity along with nutrition. But the non-significant increase in height of the supplementation group does not indicate the insufficiency of nutrients.

Gao (1991) and Sangeeta (1995) have reported an increased gain in body height of the primary school children on nutritional supplements.

However, Mukhis and Aikhashali (1985) did not find any significant effect of a shcool feeding programme on heights of supplemented children.

Comparative increase in girls and boys

Fig. 2 shows that boys and girls did not differ significantly in respect to their increase in height. In case of control group girls had an increase of 1.70 cm while boys had an increase of 1.45 cm with prophylactic dosage, height of girls increased by 1.45 per cent while boys and an increase of 1.57 per cent of their respective initial heights. Girls had an increase of 1.05 cm with supplements and 1.26 cm with supplements in boys (Table.4.22).

4.6.2.2.3 Impact on serum retinol levels

The initial mean serum retinol levels of three groups were 17.05 ± 1.34, 15.79 ± 1.24 and 14.23 ± 0.70 in control, prophylactic and supplementation group, respectively. After prophylactic dosage and supplementation the increase in serum retinol levels varying from 11.12 ± 2.61 to 13.82 ± 2.23 μg/dl, when compared to an increase of 8.40 ± 3.36 μg/dl in control group. An increase of 70.41 per cent was osberved in prophylatic dose whereas it was 97.09 per cent in supplementation group and the increase was 49.27 per cent in control group (Table 4.23).

Table 4.22. Comparative effect of feeding developed supplements on height (cm) of girls and boys

(N=30)

Supplement	Girls					Boys				
	Ref. value	n	Initial	Final	Increase	Ref. value	n	Initial	Final	Increase
Group I	123.45[a]	7	117.20 (±6.68) (94.93)[c]	118.70 (±6.77) (96.15)[c]	1.70 (1.45)[b]	124.25[a]	3	108.80 (±2.96) (87.56)[c]	110.25 (±3.99) (88.73)[c]	1.45 (1.33)[b]
Group II		4	118.27 (±8.31) (95.80)[c]	119.93 (±7.77) (97.10)[c]	1.66 (1.50)[b]		6	120.03 (±4.60) (96.60)[c]	121.60 (±14.53) (97.86)	1.57 (1.30)[b]
Group III		5	117.12 (±5.24) (95.87)[c]	118.17 (±5.43) (95.72)[c]	1.05 (0.89)[b]		5	120.96 (±2.53) (97.35)[c]	122.22 (±2.40) (98.36)[c]	1.26 (1.04)[b]

Values are mean±S.D.

[a] Indian Council of Medical Research (1989)

[b] Per cent increase as compared to initial value.

[c] Per cent increase as compared to reference value.

Figures in parentheses indicate per cent of reference value.

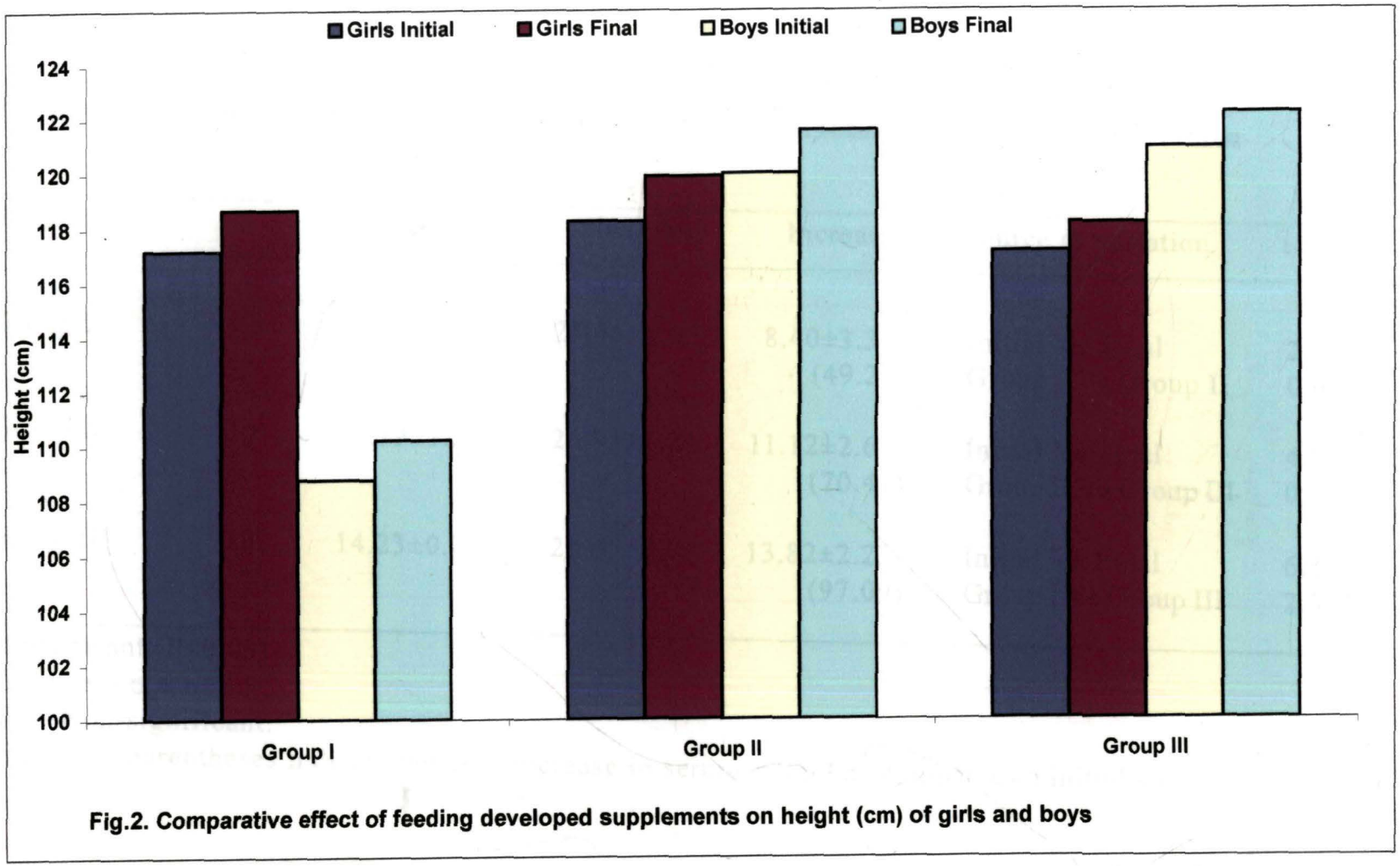


Fig.2. Comparative effect of feeding developed supplements on height (cm) of girls and boys

Table 4.23. Effect of feeding developed supplements on serum retinol (μg/dl) of school children

(N=30)

Supplement	n	Initial (kg)	Final (kg)	Increase	Source of variation	t-value
Group I	10	17.06±1.34	25.46±1.55	8.40±3.37 (49.27)	Initial Vs Final	2.50*
					Group I Vs Group II	0.64^{NS}
Group II	10	15.79±1.24	26.91±1.21	11.12±2.62 (70.41)	Initial Vs Final	4.24*
					Group II Vs Group III	0.79^{NS}
Group III	10	14.23±0.71	28.05±0.72	13.82±2.23 (97.09)	Initial Vs Final	6.19*
					Group I Vs Group III	2.34*

*Significant ($P<0.05$)
Values are mean±S.E.
NS = Non-significant.
Figures in parentheses indicate per cent increase in serum retinol as compared to initial value.

The perusal of data reveals that the increase obtained with supplementation was significantly higher ($P<0.05$) than that of prophylactic and control group. The different supplemented groups did not differ among themselves with respect to the increase obtained in their serum retinol content after feeding trials. Provision of supplements with higher levels of β-carotene content might have been responsible for the higher levels of serum retinol in supplemented groups as against the control group.

Rukmini (1994) and Manorama *et al.* (1996, 1997) reported that nutritional status in terms of serum vitamin A level improved in the groups fed with supplementary foods.

Similarly, increase in serum vit. A level of children supplemented groups as compared to those of unsupplemented groups has also been reported by Adelekhan *et al.* (1997) and Guptill *et al.* (1993).

Comparative increase in girls and boys

The trend of serum retinol increase in boys and girls was found to be gradual. In control group, girls had an increase of 52.02 per cent as compared to 44.01 per cent in boys (Table 4.24). With prophylactic dosage girls had an increase of 13.36 µg/dl while boys had an increase of 9.62 µg/dl only. With supplementation girls had an increase of 119.11 per cent and boys had an increase of 79.09 per cent as compared to their respective initial values.This trend was also seen in Fig. 3.

It can be concluded from this study that supplementary feeding of all the supplements resulted in improvement of nutritional status in terms of anthropometric and biochemical measurements which indicate a better

Table 4.24. Comparative effect of feeding developed supplements on serum retinol (µg/dl) of girls and boys

(N=30)

Supplement	Girls					Boys				
	Ref. value	n	Initial	Final	Increase	Ref. value	n	Initial	Final	Increase
Group I	25 µg/dl-90 µg/dl	7	16.05±1.37	24.90±1.68	8.35 (52.02)[b]	25 µg/dl-90 µg/dl	3	19.38±3.12	27.91±3.91	8.53 (44.01)[b]
Group II		4	14.07±1.03	27.43±1.83	13.36 (94.95)[b]		6	16.94±11.88	26.56±1.73	9.62 (56.78)[b]
Group III		5	12.82±0.55	28.08±0.66	15.27 (119.11)[b]		5	15.64±0.97	28.01±1.38	12.37 (79.09)[b]

Values are mean±S.E.

[a] Swaminathan (1999)

[b] Per cent increase as compared to initial value.

[c] Per cent increase as compared to reference value.

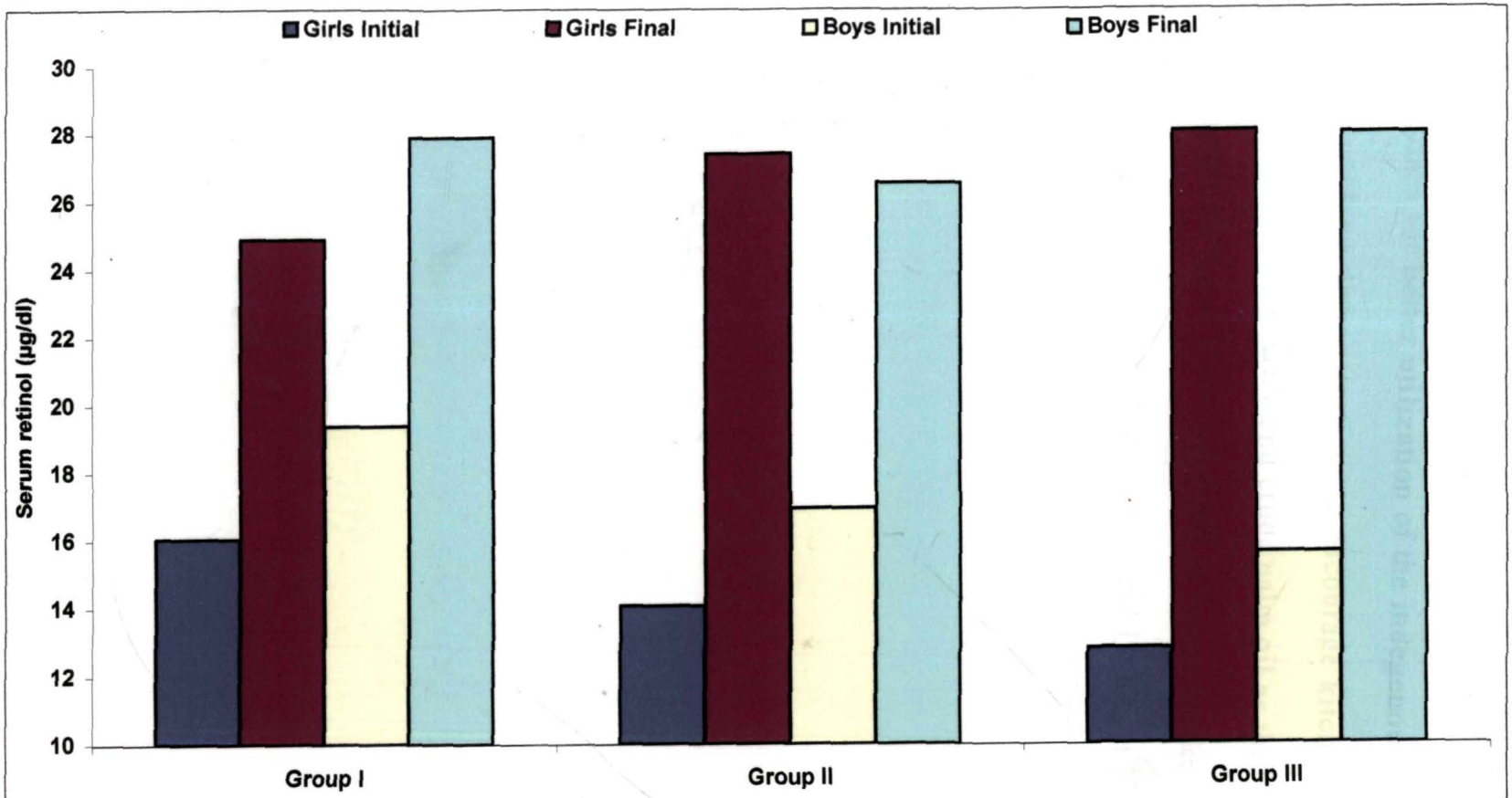


Fig.3. Comparative effect of feeding developed supplements on serum retinol (µg/dl) of girls and boys

growth pattern among experimental groups illustrating the benefits of the supplementary feeding. Nutrition education should be imported to women and children for better utilization of the indegenous vit. A. rich sources, through cooking demonstrations to encourage kitchen gardens. Emphasis should be given to use GLV and crude palm oil as the diets of the most of the respondents have been reported in lower intake of fat. Besides of having natural good proportion of SFA and USFA, it is also providing β-carotenes and tocopherols.

CHAPTER - 5

SUMMARY AND CONCLUSION

The present study was conducted to develop supplementary foods based on crude palm oil (*Elaeis guineensis*), their nutritional evaluation, effect on storage and to investigate the effects of feeding of developed supplements on nutritional status of school children. The investigation was conducted in IV phases. During phase I various supplements utilizing crude palm oil were developed and subjected to acceptability trials and these developed supplements were subjected to chemical analysis for their nutritional composition.

In phase II these supplements were subjected to storage studies for 45 days with 15 days interval. In phase III, three supplements were selected based on their organoleptic scores, ease in preparation and β-carotene content. Thirty children were selected randomly from the Govt. School, Canal Colony. Diet survey of school children (7-9 years old) from the Govt. School, Canal Colony, Hisar was conducted for obtaining the information regarding their dietary intake and nutritional status. The nutritional status was assessed using parameters like anthropometric measurements, clinical and biochemical assessment. These were divided in to three groups of 10 children each such that all groups had similar dietary intake and

anthropometric measurements. One group was given the selected supplements ,second group was given with single dose of oral vit. A and third group served as the control group and was given no supplements. The three supplements selected for feeding were biscuit, nankhatai and nutritious ladoo. Children were instructed to eat the given supplements daily in front of the investigator during their lunch break. Home visits were made to check up any problem regarding digestion or difficulty with intake of supplementary foods. Finally during the phase IV at the end of one month feeding trials, the nutritional status of children fed on the supplements and control group children was again assessed in terms of dietary, anthropometric, clinical and biochemical assessments and compared to each other.

During the survey, it was observed that daily mean intake of all food stuffs, i.e. cereals, pulses, vegetables, fruits, fats and oils, milk and milk products and sugar and jaggery were lower than RDI. It was also found that children had inadequate nutrient intake. Their daily energy intake ranged between 854.87 - 898.62 Kcal. The protein intake ranged between 23.1 - 24.93 g/day. Fat intake was also lower than RDA ranging between 10.82 - 11.05 g/day. Vitamin A in terms of β-carotene intake ranged between 1140.47 - 1179.65 µg/dl.

Nutritional status of children as assessed in terms of anthropometric and biochemical measurements reflected to be poor i.e. weight, height and serum retinol levels were lower than the standards. The mean values of weight, height were found to be 18.91 kg and 116.58 cm. The observed

mean serum retinol value was 17 µg/dl. Night blindness was found in 23.33 per cent of children. Bitot's spots was seen in 10.00 per cent of children.

All the supplements developed were found to be organoleptically acceptable to the panel of judges. The moisture, fat, ash and protein content of developed supplements ranged between 0.47-41.78, 17.24-33.74, 0.62-3.93 and 4.37-12.34 per cent, respectively. Energy content of the developed products ranged between 284.04 - 639.43 kcal per 100 g.

The three supplements selected for feeding were biscuit, nankhatai and nutritious ladoo. Their protein, energy and β-carotene values ranged between 3.05-3.8 g, 170.73 - 230.19 kcal and 1347.10-1363.75 µg/g, respectively. With these supplements the daily energy intake was ranged between 1061.51 - 1094.95 kcal. The fat, protein and vitamin A intake of the three supplements ranged between 10.95-22.96 g, 23.95 - 27.75 g and 1141.83 - 2457.65 µg/day, respectively.

Supplemented groups showed significantly higher increase in body weight, height and serum retinol level than control group. Nonsignificant differences existed between the supplemented groups themselves i.e., among boys and girlsof same group.

Thus, it may be concluded that developed supplements were acceptable to children and could serve as a good supplement for improving the nutritional status of young children. Moreover, these supplements could be prepared easily from locally available food stuff by the mothers as they consume less labour, time and fuel.

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APPENDIX-I

Score sheet for taste panel/data under hedonic scale

Name: Dated:

Product:

Test these samples and check how much you like or dislike each one. Use appropriate scale to show your attitude by assigning points that best describe your feeling about thesample. An honest expression of your feeling will help us.

Code No.	Colour	Appearance	Flavour	Texture	Taste	Overall acceptability

Rate	Organoleptic score
Very desirable	9
Desirable	8
Moderately desirable	7
Slightly desirable	6
Neither desirable nor undesirable	5
Slightly undesirable	4
Moderately undesirable	3
Undesirable	2
Very undesirable	1

Note: Please rinse your mouth before and after testing each product.

Signature

ENUMERATION SCHEDULE

I.D.No. Dated:

I. General information

1. Name of the child:
2. Age
3. Sex
4. Anthropometry: Weight: Height:
5. BMI
6. Details of family members

Name	Age	Sex	Occu-pation	Edu-cation	Income	Relation to child

7. Type of family: Nuclear/Joint
8. Annual income of family:
9. Other sources of income to the family:
   (a) Income from poultry/dairy
   (b) Income from other sources

DIETARY SURVEY

Meal pattern	Item consumed	Amount	Ingredient
Bed tea			
Breakfast			
Mid morning (school break)			
Lunch			
Evening tea			
Dinner			
Any other			

II. Schedule for assessment of Clinical & Biochemical signs of Vit. A deficiency

Clinical Signs and Symptoms

1. Night blindness
2. Bitots spots
3. Conjunctival xerosis
4. Corneal xerosis
5. Kerato malacia

Biochemical assessment

Serumretinol	Before feeding	After feeding

ABSTRACT

a)	Title thesis	:	**Utilization of crude palm oil for development of vit. A rich supplementary foods**
b)	Full name of degreeholder	:	**T. SUPRAJA**
c)	Title of degree	:	Master of Science
d)	Name and address of Major Advisor	:	Dr. (Mrs.) Salil Sehgal Professor Dept. of Foods & Nutrition CCS Haryana Agril. University Hisar-125 004, India
e)	Degree awarding University/Institute	:	CCS Haryana Agril. University Hisar-125004 (Haryana), India
f)	Year of award of degree	:	2001
g)	Major subject	:	Foods and Nutrition
h)	Total no. of pages in thesis	:	159
i)	No. of words in the abstract:		Approx. 250

The present study was undertaken to develop nutritional supplements utilizing crude palm oil (*Elaeis guineesis*), their nutritional evaluation both in fresh and storage conditions, to study the shelf life of the products and to study the effect of feeding these supplements on the nutritional status of school children. A survey was conducted on school going children (seven to nine yrs old) from Govt. School, Canal Colony, Hisar for obtaining information regarding their nutritional status and thirty school children were selected for further study. Twelve supplements utilizing crude palm oil were developed which provided at least 1345 µg of β-carotene per day. The selected children were further divided into three groups of ten children each. The first group was acted as a control group. The second group was fed with oral vit. A and the other group was fed with the supplementary foods biscuit, nankhatai and nutritious ladoo which provided 5 g of crude palm oil per serving for a period of one month.

Majority of the subjects were vegetarian. Daily mean intake of cereals, pulses, vegetables, fruits, milk and milk products, fats and oils, sugar and jaggery were lower than RDI. Mean nutrient intake in boys and girls was significantly ($P<0.05$) below RDA. Mean values of anthropometric measurements and serum retinol levels were below reference value in all children. Overall clinical picture was also poor.

All the developed supplements were acceptable and of good nutritive value. Feeding of developed supplements resulted in significantly higher body weight and serum retinol levels than the control group.

Therefore, present findings reveal that developed supplements may be used as a good supplement for improving the serum retinol level of young children and easily prepared at home by mothers.

T. Supriya

SIGNATURE OF STUDENT

Ssehgal 8/01/2001

MAJOR ADVISOR

HEAD OF THE DEPARTMENT