Review of Literature

II. REVIEW OF LITERATURE

The literature pertaining to the present study on "Acceptability and Supplementation of Red Palm Oil on Selected Target Groups" is reviewed under the following headings :

A. Nutritional Scenario of Young Children
B. Significance and Deficiency of Vitamin A - A point of great concern
   B-1. Nutritional Significance of Vitamin A
   B-2. Prevalence of Vitamin A Deficiency
   B-3. Consequence of Vitamin A Deficiency
   B-4. Preventive Measures to Combat Vitamin A Deficiency
C. Red Palm Oil (RPO) - the Nutrients Dense Oil of Tomorrow is a Nature's Health Supplement
   C-1. Production of RPO
   C-2. Dietary Uses
   C-3. Nutritional Significance
   C-4. Health Benefits and
   C-5. Effects of Supplementation of RPO on Nutritional Status with Special Reference to Vitamin A Status of Young Children.

A. NUTRITIONAL SCENARIO OF YOUNG CHILDREN

Good nutrition is the fundamental requirement for positive health, functional efficiency and productivity. Nutrition Science provides abundant evidence on the importance of nutrition, not only in promoting proper physical growth and development but also in ensuring adequate immunocompetence, cognitive development and work capacity. For a nation

to be healthy, strong and productive, the nutritional status of its people especially young children must be good (Vijayalakshmi and Amirthaveni, 2001).

Two third of the World's children are in developing countries and a quarter of them live in South Asia. School going children currently constitute about 25 per cent of the population in developing countries (Torres *et al.*, 2002).

Ramalingaswami (1999) reviewed that children in South Asia are on an average more malnourished than their counterparts in other developing and developed countries. In South Asia, 33 per cent are born small (LBW) in comparison with 18 per cent for developing countries as a whole. Fifty two per cent of children are stunted in South Asia in comparison with a figure of 30 per cent in all developing countries put together.

According to UNICEF and World Bank Reports, 23 per cent of children in India are malnourished. Despite the significant progress that has been made in the technology of food production, more than half of all under 4 years old in India are still moderately or severely malnourished (Claeson *et al.*, 2000).

India has less than 20 per cent of the world's child population, but it has up to 40 per cent of malnourished children in the world. India, Bangladesh and Pakistan together account for half of the malnourished children in the world (Ramalingaswami, 1999). According to the report of the status of World's Children (2001), 53 per cent of Indian children are underweight, 53 per cent stunted and 18 per cent are undernourished in moderate and severe categories (Goyle, 2001). The problem of malnutrition

encompasses a spectrum of deficiencies. Together they contribute to a great deal of morbidity and ill health, growth retardation, reduced level of physical and development activity in children (Seshadri, 1997). Extensive diet surveys carried out in different parts of India both in rural and urban areas indicate that the diets are predominantly based on cereals. Diets of the poor income groups are deficient in several nutrients namely Energy, Vitamin A, Calcium, Iron, Riboflavin, Iodine and Vitamin C. Deficiency of these nutrients occur more frequently and to a greater degree among children (Gopalan *et al.*, 1999). The basic cause of these deficiencies is lack of adequate intake of vital nutrients through the diets compounded by poor bioavailability (UNICEF, 2001).

Holder *et al.* (2000) opine that 50 per cent of 1½ to 4½ year old children have nutrient intake below the Reference Nutrient Intake (RNI) with further eight per cent below the Lower Reference Nutrient Intake (LRNI).

Chopra (2003) noted that undernutrition continues to be a primary cause of ill health and premature mortality among children in developing countries (Nandy *et al.*, 2005). Malnutrition in children is a global problem being prevalent in all sections of the society.

Harves (1999) observed that malnutrition especially undernutrition in the early stage of life appears to be associated with an increased risk for the degenerative diseases and stunting appears to be associated with over weight and obesity later in life.

Singh (2003) and Dutta (2003) reviewed that the prevalence of Protein Energy Malnutrition among preschool children is high in developing

countries including India. In India, 53 per cent of children are wasted and 52 per cent are stunted in growth.

Chunmig (2003) and Amir (2002) quoted that chronic energy deficiency along with low intake of micronutrients results in poor physical growth and decreased IQ especially in early childhood. Malnourished children tend to have lower IQ and impaired cognitive ability and physical performance and then the capability of their adult life.

Brown (2002) quoted that malnutrition has the greatest impact on mental development when it is severe and occurs during the critical period for brain cell manipulation for humans, this vulnerable period begins during pregnancy. Under nutrition is one of the major public health problems in India as in most developing countries. Young children and women of the reproductive age group are considered to be the most vulnerable to undernutrition.

According to Gopalan (2005) that the deficiencies of protein, energy, vitamin A, Iron and Zinc, plague children the world over. In developing countries, such deficiencies cause or contribute to nearly half the death of children and inflict blindness, stunted growth and vulnerability to infection on million more. The other nutrients which have lower or deficient level in children's diets are Calcium, Iron, Zinc and Vitamin A and B_6 and are responsible for the occurrence of micronutrients deficiency diseases (Carpenter, 1998).

Among the various nutritional deficiency problems, micronutrient deficiency diseases are a major health problem of epidemic proportion. Micronutrients deficiencies such as Vitamin A Deficiency (VAD), iron

deficiency anemia (IDA) and Iodine Deficiency Disorders (IDD) are significant health problems. It affects the life of human beings throughout their life cycle, especially young children, adolescents and women of reproductive age. The consequence of micronutrient malnutrition includes increased risk of childhood and maternal mortality and morbidity, nutritional blindness, physical disability, mental retardation and lowered physical work capacity, leading to lowered productivity. In India, varying degree of malnutrition namely, Protein Energy Malnutrition, iron, vitamin A and iodine deficiencies which are preventable and within control are affecting human resources making them ineffective (Gopalan, 1996).

Sommer (2004) states that vitamin A is the foremost micronutrient whose deficiency causes a wide spectrum of disorders commonly referred to as vitamin A deficiency, encompassing the full spectrum of clinical consequences associated with sub-optimal vitamin A status, which occurs mainly during childhood and pregnancy. In children, lack of vitamin A causes severe visual impairment and blindness and significantly increases the risk, common childhood infection as diarrhea and measles.

Sachithanantham and Chandrasekhar (2005) report that globally 127.2 million preschool children are affected by Vitamin A Deficiency which represents 25 per cent of preschool children in high risk regions of the developing world. Forty four per cent of them live in South and South East Asia, whereas 26 and 10 per cent live in the African and Eastern Mediterranean regions respectively. The largest numbers live in India (35.3 million), Indonesia (12.6 million), China (11.4 million) and Ethiopia (6.7 million). Approximately 6.5 per cent (8.2 million) live in the region of America. Anemia is estimated to affect 3.5 billion individuals in the

developing world or well over two persons out of three. More than 320 million people in India suffer from iron deficiency anemia: with the highest prevalence among young children and women (Nutrition Network News Letter, 2001).

Bamji *et al.* (2003) point out that anaemia is a major global problem affecting 20-70 per cent of the population in various countries. In India, it is an important public health problem affecting people from all walks of life. The disease is of particular significance in preschool and school going children and pregnant women because of the high prevalence (50-70 per cent) and the adverse functional consequences. In school children, anemia impairs scholastic performance and in young women the reproductive performance. Anemia is directly or indirectly responsible for 10-20 per cent of maternal death, high incidence of premature births and intra uterine malnutrition (Thirumanidevi and Uma, 2005).

Proper nutrition at the growing stages of life not only helps to promote health but also prevent the occurrence of deficiency diseases and other health hazards (SriLakshmi, 2004) Hence, proper nutrition is the most important factor of growth in growing children. Childhood is a period of rapid physical and mental growth and development and child's nutritional requirements are higher per unit of body weight than those of adult (Devadas and Jaya, 1993). Adolescence is another period characterized by rapid increase in height and weight, hormonal changes resulting in sexual maturation and causing wide swings of emotion. In addition, it is an anabolic phase of life and warrants increased nutrient requirement for unit body weight (Morgan, 2003).

According to ICMR (2004), the calorie needs increase with the metabolic demands of growth and energy expenditure of the growing children. Although individual needs vary, girls consume less kilocalories of energy than boys. Diet surveys carried out in India have shown that the diet consumed by children (10-18 years) is both qualitatively and quantitatively deficit in calories, protein, vitamin A, riboflavin, folic acid and iron.

Body requirements of calories are increased steadily for children. Requirements remain almost same for girls from 7-12 years. Requirements for boys increased from 7-9 to 10-12 years as there is a gradual increase in need because reserves are being laid down for the demands of the approaching adolescent period. The increased requirement of protein meets the demands of growth. Girls require more protein between 10-12 than boys for approaching menarche. For most adolescents, eating to satisfy appetite offers a reasonably sensitive indicator of energy needs. Protein needs represent 12-14 per cent of energy intake. The protein intake usually exceeds 1g/kg body weight. This meets growth needs and for the pubertal changes in both sexes and for the development of muscle mass in boys (Sri Lakshmi, 2006).

Children require more calcium than adults to meet skeletal growth demands. As the blood volume is increased iron requirements are also increased. In childhood, from the second birthday to the twelfth in the boys and to the tenth in the girls, the mean increase in body weight is 2.5-2.7 kg/year, equivalent to an iron requirement of 0.3 mg/day. The daily requirement is further increased by a rise in the haemoglobin concentration by about one gram per deciliter. The amount of iron required to replace

losses gradually increases from 0.2 mg/day during infancy to 0.5mg/day in the twelfth year (Krause, 2004).

Calcium and iron are particularly needed during adolescence. About 150 mg of calcium is retained each day for the increase in bone mass. The girls need to ensure adequate intake of iron as they lose 0.5mg per day by way of menstruation. The daily menstrual loss of iron is blood lost during the menstrual period overlapped over a month. If this loss is not replaced, it predisposes, to iron deficiency anemia. During adolescence, there is an increase in body mass corresponding to about 4.3kg/year in the male and 4 kg/year in the female. With a further increase in haemoglobin by 2g/dl in the female, the respective requirement for growth alone is 0.7 mg/day in males and 0.45 mg/day in female while the obligatory losses also increase with age (Rao, 1997). The need for B complex vitamins especially thiamin, riboflavin increases directly with increased calorie intake. Folacin and B_{12} are essential for DNA and RNA synthesis and needed in higher amounts when tissue synthesis is occurring rapidly. Skeletal growth requires vitamin D while the structural and functional integrity of newly formed cells demands on the availability of vitamin A, C and E (Bamji *et al.*, 2003).

Hence, nutritional adequacy is the key determinant of the quality of human resources every where. Improvements in nutrition of the young child are desirable not only for their expected, impact on physical growth but also to reduce the risk and consequence of deficiency diseases and to maximize physical and psychomotor development and subsequent performance (Roy and Ray, 2000).

B. SIGNIFICANCE AND DEFICIENCY OF VITAMIN A - A POINT OF GREAT CONCERN

B-1. Nutritional Significance of Vitamin A

Fat soluble vitamin A is an essential micronutrient, which cannot be synthesized by the body and hence consumption through food is necessary. Retinol, the preformed vitamin A is found in animal foods such as egg, milk, liver and fish oil. Plant foods such as bright yellow, orange, red and dark green vegetable and fruits contain provitamin A called carotenoids. Of the several carotenoids, beta-carotene has the highest biological activity of vitamin A. (Vijayaraghavan, 2003).

Wardlaw and Insel (2002) and Rao (2005) stated that it is called as anti-infection vitamin, as it helps the body to combat bacteria, parasitic and viral infections. In the immune system, vitamin A is needed for the differentiation that produces the different types of immune cells. Adequate vitamin A status decreases the severity of measles and other infectious diseases (Brown, 2002).

Retinoic acid is known to function like a hormone in the control of growth and development of tissues in the musculo-skeletal system. It is also important for bone growth, because it turns on the cells that remove old bone cells, prior to the deposition of new bone cells (Smolin and Grosvenor, 2000 and Sommer and West, 1996).

Each of the three active forms of Vitamin A performs important functions in the body; retinal is needed for reproduction, retinoic acid supports growth and allows cells to mature and differentiate, and retinol is

crucial in night and colour vision, perhaps the best known role of vitamin A (Wardlaw and Insel, 2002).

Without vitamin A, mucus forming cells deteriorate and no longer synthesize mucus, an essential lubricant used throughout the body. The eye, especially the cornea, is greatly affected by the loss of mucus, which lubricates the eye surface and washes away dirt and other particles settling on the eye (Krause, 2004).

Guthrie (2001) quoted that insufficient mucus production in the eyes, intestinal tract and lungs, deterioration of many types of cells and reduced activity of some immune-system, cells leave a person quite vulnerable to infection. This is the reason that the night blindness in children is accompanied by diarrhea, respiratory tract infection and corresponding morbidity and increased risk of dying from measles. Conversely immune response to certain antigens increases when children deficient in vitamin A are provided with the vitamin A supplements.

Semba (1998) states that the ability of retinoids to influence cell development, coupled with their ability to increase the activity of immune system cells, could make them valuable tools in the fight against cancer, especially skin, lung, bladder and breast cancer.

Bhaskaram (2001) revealed that epidemiological evidence shows that regular consumption of foods rich in carotenoids decrease the risk of lung cancer, reproductive cancer and oral cancer. The many double bonds present in some carotenoids molecules make them effective traps for the energy in highly reactive species of oxygen (Singlet Oxygen) and peroxides (such as H_2O_2), harmlessly releasing the energy as heat. Singlet Oxygen and

peroxides are two of the many oxidizing agents that can probably initiate the cancer process. By adding to block the effects of oxidizing agents that can probably initiate the cancer process. By acting to block the effects of oxidizing agents, carotenoids are called antioxidants.

Vitamin A is essential for proper growth, differentiation and also involved in reproduction. Vitamin A is also known to be involved in the synthesis of glycoprotein. Retinoids are found to alter gene expression resulting in the prevention of some forms of neoplastic transformation (Nestel and Nalubola, 2003).

Carotenoids play a role in preventing heart disease in persons at high risk, possibly linked to their anti-oxidants capability. Many scientists recommend that consumption of a total of least five serving of red, yellow, orange and other fruits and vegetables per day, as part of an over all effort to reduce the risk of heart diseases (Nutrition.com).

Krause (2004) have indicated that vitamin A is mainly associated with vision. The retina contains two distinct photoreceptor systems. A specific vitamin A aldehyde is essential for the formation of rhodopsin (the high molecular weight glycoprotein part of the visual pigment within the rods) and for the normal functioning of the retina. By virtue of this relation to the visual process, retinol and retinal are involved. A person with VAD has an impaired adaptation to darkness.

B-2. Prevalence of Vitamin A Deficiency

The World Health Organisation has estimated that over 250 million children world wide have deficit vitamin A stores (WHO, 1999). Between

1991-1995, estimates suggested that while the number of countries affected by VAD remained the same, cases of xerophthalmia fell from 13.4 to 2.8 million. The latest estimates are shown in the Table below.

TABLE 2.1
ESTIMATED PREVALENCE OF XEROPHTHALMIA AND VAD

REGION	XEROPHTHALMIA (Million)	VAD (Million)
South Asia	1.58	32-60
East Asia / Pacific	0.40	15-30
Latin America / Caribbean	0.12	5-10
East / Southern Africa	0.53	10-18
West Central Africa	0.45	10-17
Middle East, North Africa	0.12	3-5
Total	3.30	75-140

As shown in the Table, while the number of children with signs of xerophthalmia remains much the same as in 1995, the prevalence of VAD has decreased to 75-140 million (Frigg, 2001). These numbers do not take into account VAD in older children and adults. Thus, it seriously under estimates the total magnitude. Sub clinical deficiency is associated with increased risk of severe illness and death, especially in young children (Ananthanarayanan, 2001).

It is estimated that VAD is a public health problem in 96 countries. Africa has the highest prevalence of clinical vitamin A deficiency while the highest number of clinically affected are in South East Asia. Among the children under five years of age affected by VAD, around three million have

signs of xerophthalmia. Nevertheless, most of the children affected by VAD (140 and 250 million) present only subclinical manifestations, yet live with a greater risk of mortality and the risk of developing severe infections (WHO, 1999).

Indonesia has a huge population of 210 million people with a prevalence of blindness of 1.5 per cent. In the United Kingdom, the figure is 0.3 per cent (Burrough, 2004).

Vitamin A deficiency is widespread in developing countries and India alone accounts to nearly one third of the global problem. According to the 1997 estimates in India, approximately 2.7 million children under five years of age exhibit signs of clinical xerophthalmia and another 250 million have low body vitamin A stores who are 20 times more at risk of death from severe infections (Ghai and Gupta, 1999).

On the basis of the available information 5-10 per cent of Indian children show clinical evidence of vitamin A deficiency and 5-10 million children develop xeropthalmia each year (Kulkarni *et al.*, 2001).

In India, surveys carried out by the National Nutrition Monitoring Bureau (NNMB) and Integrated Child Development Services (ICDS) indicate that the prevalence of Bitot's spot in preschool children (1-5 years) ranges between 1-5per cent in different parts of the country. There are very few studies reporting the incidence of corneal lesions in India. The corneal xerophthalmia has been reported to be0.05 to 1.0 per 100 preschool children in South India. Community studies carried out in Andhra Pradesh, Tamil Nadu and Uttar Pradesh indicate that 30-50 per cent of children have retinol

level below 20mg/dl which is a cut level given by WHO (www.sightandlife.org).

Toteja *et al.* (2002) carried out a multicentric study to assess VAD disorders (Bitot's spot and corneal scars) in 1,64,512 children and night blindness among 1,13,200 children from 16 districts of 11 states of India showed that the highest prevalence at Bitot's spot (14.71%) corneal scar (0.5%) and night blindness (5.17%) in children. Annually, VAD contributes to the death of 2-3 million children, to an estimated 5,00,000 cases of permanent blindness.

The prevalence rate of VAD are higher in school age children than in younger age group but severe forms of the deficiency resulting in blindness are confined to children below three years (Reddy *et al.*, 1993). Five to fifteen per cent (6.6 to 9.2 million) of preschool children vary greatly between states (Sachdev, 1996). Vitamin A surveys had proved an increased prevalence with advancing age. Vitamin A prevalence survey on pre school children showed that the prevalence of Bitot's spot increased for 0.9 per cent in one year old to 7.3 per cent in 5 year old children. The prevalence was even higher among school age children. Roy and Ray (2000) observed that the prevalence of VAD varied from less than one per cent to greater than nine per cent in different parts of India. According to NIN, prevalence of VAD was lower in Kerala (0.3%).

As per the data of Rahi and Herrera (1995), the overall proportion of morbidity due to severe VAD in Tamil Nadu is 19 per cent with variation within the state with an urban rural gradient from eight per cent to 30 per cent.

Goyle (2001) confirmed that thus, an overview of the prevalence of vitamin A deficiency among the preschool and school going children will help to determine the existence severity and extent of VAD in a population. Also this will help to recognize vitamin A deficiency as a potential problem of children at larger and not as a sole problem of preschool children.

B-3. Consequence of Vitamin A Deficiency

Vitamin A deficiency is one of the most frequent nutritional deficiencies in the world and is a threat to the health, sight and lives of million of children in the developing world (Sommer, 2001).

Mahan and Stamp (2004), confirmed that the deficiency of vitamin A is caused by a low intake of vitamin A in relation to need. Primary deficiency of vitamin A and provitamin A-carotenoids, result from inadequate intake of preformed Vitamin A and provitamin A carotenoids. Secondary deficiency result from malabsorption due to insufficient dietary fat, biliary or pancreatic bile insufficiency and impaired transport due to beta-lipoproteinemia, liver disease, PEM or zinc deficiency.

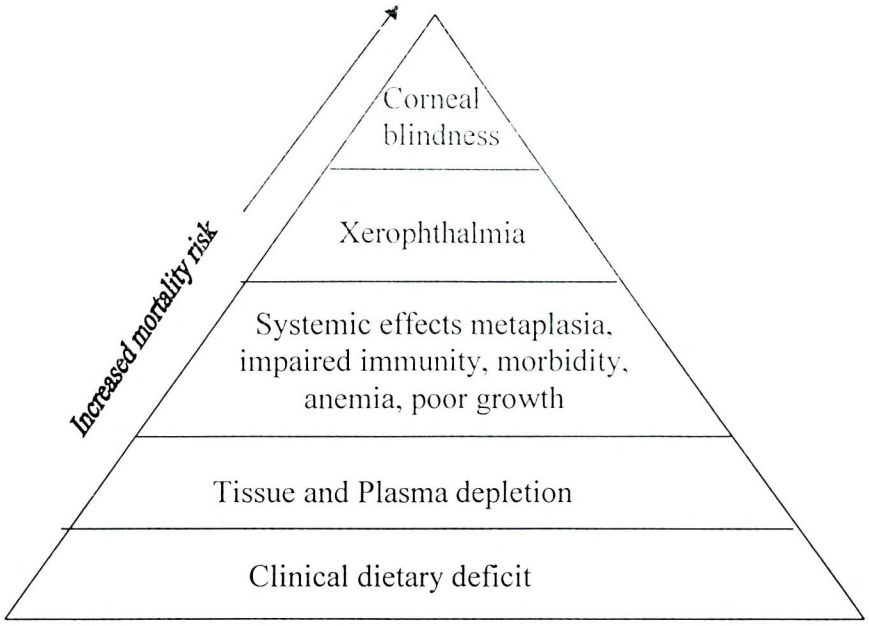
Thus, insufficient dietary intake and inadequate absorption of vitamin A result in deficiency, often precipitated by a range of illness and infections including diarrhea, acute respiratory infections and measles (Nutrition Network News Letter, 2001).

Gopalan (2004) pointed out that the food habits governed by traditional beliefs and faulty socio-cultural practices, also contribute to insufficient dietary intake of vitamin A.

Swaminathan (2002) highlighted that the most widely known vitamin A deficiency problems are related to the eyes collectively, referred to as xerophthalmia or 'dry eyes', night blindness caused by a reversible lack of retinol in the retina, conjunctival xerosis, Bitot's spots can be accumulation of cell debris on the conjunctival surface, corneal xerosis, corneal ulceration and keratomalacia which results in irreversible blindness.

UNICEF (1995), observed that the experimental studies have demonstrated a close association between vitamin A deficiency and susceptibility to infection. Integrity of the epithelial cell, which is the first barrier to infection, is compromised in VAD and this results in an increased incidence of infections. Children with mild xerophthalmia or sub-clinical VAD therefore are at an increased risk of common childhood illness. Vitamin A deficiency has a wide range of effects on growth and development in children because of its reduced effectiveness on the immune system. Even in moderate level of deficiency, it leads to stunted growth and increased severity of infection. It has become increasingly clear that even mild VAD reduces the children's resistance to diarrhoea which kills 2.2 million per year and measles nearly one million annually.

The diagram illustrates the increasing seriousness of the health consequences of VAD (Gillespie, 2001).



The magnitude of VAD

Vijayaraghavan (2003) pointed out that nutritional blindness due to xerophthalmia is an important public health problem among young children in India and several other developing countries. The term xerophthalmia encompasses all ocular manifestations of vitamin A deficiency. It includes the structural changes affecting conjunctiva, cornea and occasionally retina and also the biophysical disorders of retinal rod and cone functions.

For children, lack of vitamin A causes severe visual impairment and blindness and significantly increases the risk of severe illness and even death from common childhood infections such as diarrhoeal diseases and measles (WHO, 2001).

One of the first signs of VAD is impaired vision from the loss of visual pigments. This manifests clinically as night blindness or nyctalopia. This impairment of dark adaptation (the ability to adopt from being in a bright light or moving from a bright light to a dark room) individually with

night blindness have poor visual discriminatory ability and poor visibility in dim light (Institute of Medicine, 2000).

VAD leads to failure in systemic functions characterized by impaired embryonic development, impaired spermatogenesis, spontaneous abortion, anemia, impaired immuno competence and fewer osteoclasts (Mahan and Stamp, 2004).

Whitney and Rofles (2002), observed that the other signs of deficiency of vitamin A include dry, hard and rough or prematurely aged skin, skin blemishes, in which the cells of the skin harden and flatten, loss of sense of smell, drying and hardening of salivary glands in the mouth, allowing for a susceptibility to infection, loss of appetite and weakened immune system, loading to frequent respiratory, digestive, bladder, vaginal and other infections. Hair losses its shine and lusture and finger nails become brittle.

Hypovitaminosis A in young children is always accompanied by infectious diseases, especially affecting the gastrointestinal and respiratory tracts. Vitamin A has been recognized for many years to have several important effects including those on growth, immune status and cell development and turn over (Xerophthalmia Club, 1986).

According to a Community Study in India, Bhaskaram (1998) reports that chronic nutritional deficiency of vitamin A may effect structural integrity of cornea which will compound the impact of measles virus and secondary infections.

Reddy (2003) confirmed that severe vitamin A deficiency predisposes the individual to infection. It is frequently associated with some degree of PEM or other micronutrients deficiency. These deficiencies themselves have important influence on the immune system. Increased bacterial colonization in the respiratory epithelium was reported among children with VAD.

Population with the highest prevalence of VAD consume low amount of animal foods and fruits rich in beta carotene. In severe Protein Energy Malnutrition, retinal binding protein synthesis is impaired. Zinc and iron deficiencies also interfere with the utilization and transport of stored retinal (www.adb.org).

For effective absorption and utilization of vitamin A and carotenoid, the diet should contain adequate amount of fats. When fat intake is low, vitamin A deficiency results from the inability to absorb fat soluble vitamin A (Smolin and Grosvenor, 2000).

B-4. Preventive measures to combat Vitamin A Deficiency

The objective of the prevention program will depend on several factors such as the severity of the problem and availability of financial, material and manpower resources. The objective can either be prevention of blindness attributes to xerophthalmia or improvement of vitamin A status of target groups. While the former involves prevention and control of clinical xerophthalmia, the later requires raising of serum vitamin A level of an individual, thereby in the community (Vijayaraghavan, 2003).

WHO (1988) proposed an overall strategy for prevention and control of vitamin A deficiency, which includes long, medium and short-term

measures. The short-term approach is based on nutrient supplementation usually the provision of a high dose of vitamin A. Striking reduction in childhood morbidity and mortality has been observed among the community which receive regular supplements of vitamin A. The medium term approach is fortification and supplementation of some foods rich in the particular nutrient and the long term approach of increasing dietary intakes of vitamin A, is feasible in most areas because vitamin A precursors (carotene) are contained in relatively large amounts in many inexpensive vegetable origin foods like green leafy vegetables and yellow and orange vegetables and fruits and Red palm oil.

Prophylatic supplementation programme is linked with the routine immunization programme. First dose of 1,00,000 IU is given to children of nine months along with measles immunization and the second and subsequent doses (2,00,000 IU) are given every six months until the children complete three years of age (Rao, 2005).

Sachithanathan and Chandrasekhar (2005) opine that vitamin A supplement at the time of DPT immunization results in an increased antibody response to diphtheria compared to that of non-supplemented infants.

Food fortification or enrichment of widely consumed foods with vitamin A is another strategy to prevent and control VAD. Foods, which are consumed daily by all the sections of the community with little variation in the intake are generally selected for the purpose (Craft, 2000). Srilakshmi (2006) reviewed that consuming an adequate supply of β-carotene rich foods

for the population is one of the most important pre-requisites for promoting the dietary intake of vitamin A.

The strategy to prevent VAD should be a combination of a long-term programme of nutrition education and improvement in household food security and short-term periodic massive dose of vitamin A. There is also a need for intensification of research and development activities to identify technologies to increase the production and consumption of less familiar β-carotene rich foods such as Red Palm Oil and Spirulina. Involvement, motivation and mobilization of community are essential for achieving the goal of prevention of Vitamin A Deficiency was suggested by Rao (2005).

Food based approaches are considered to be the most sustainable and cost effective in enhancing vitamin A status and in reducing VAD. However few consistent efforts have been directed towards the realization of this approach. Besides encouraging the use of environmental sources of carotene, there is a need for promotion of more potent food sources like Red Palm Oil. The Red Palm Oil, an underexploited, is an unique cooking oil, meeting the physiological needs of human beings of all ages. This oil has gained much prominence as a natural dietary therapy in overcoming vitamin A induced blindness that is the scourge of a million children around the world (Benade, 2003).

In human diet, an oil is invariably used as a medium of cooking. Red palm oil is an excellent source of beta-carotene, provides 400 microgram of beta-carotene per gram. It is a well known fact that beta-carotene is the most efficient pro vitamin A. Thus, a small intake of 3-5 gram of Red palm oil daily is sufficient to meet the vitamin A needs of the growing population.

Therefore, it is a promising alternative in any strategy for combating vitamin A deficiency (Gnanasundaram, 2001).

C. RED PALM OIL (RPO) THE NUTRIENTS DENSE OIL For TOMORROW, IS A NATURE'S HEALTH SUPPLEMENT

C-1. Production of RPO

For about 5000 years, oil palm has been an important food crop for mankind. From its origin in Africa, oil palm has crossed the oceans of the world, to become an important plantation crop. The oil palm of commercial significance, Elaeis guineesis is planted on large plantations in Malaysia and has emerged as the most prolific oil bearing crop in the world. It has an economic life of 20-25 years and annually bears 8-12 fruit bunches each weighing between 15-25 kg. Each fruit bunch carries 1000-3000 fruits. Each palm tree produces about 40 kg of palm oil a year (Malaysian Palm oil Information Series, 2003).

Oil palm is produced in 42 countries worldwide on about 27 million acres. Production has nearly doubled in the last decade and oil palm has been the world's number one fruit crop in terms of production for almost 20 years. The average yield is 10,000 pounds per acre, ranging from 2,700 to 2,40,000 pounds per acre. Production of oil from African oil palm is more than four fold that of any other oil crop, which has contributed to the vast expansion. Over the last few decades showed that oil palm production has increased exponentially since the 1960's (www.uga.edu/fruit/oilpalm.htm).

The oil palm is mainly distributed within 10°C of the equator though it is now grow in most African countries including other countries such as

Brazil, Colombia, Ecuador, Panama, Cost Rica, The Solomon Island, Philippines and India are developing palm plantations. The table below highlights the top ten countries which produce palm oil worldwide.

TABLE 2.2
TOP TEN COUNTRIES
(PER CENT OF WORLD PRODUCTION OF PALM OIL)

Malaysia	- 44%	Cote d'/voire	- 1%
Indonesia	- 34%	Equator	- 1%
Negeria	- 6%	Cameroon	- 1%
Thailand	- 3%	Congo	- 1%
Colombia	- 2%	Ghana	- 1%

(http:// www.uga.edu/fruit/oil palm.htm)

The world production of palm oil by major oil palm growing countries indicated a steady progress in the production of palm oil for edible and non edible uses (Poku, 2002).

Malaysia is the world's largest producer and exporter of palm oil. In 2003, it produced 13.35 million tonnes or 47.8 per cent of the world production of 27.92 million tonnes. Malaysia exports 12.27 million tonnes constituting 56.3 per cent of palm oil in the world trade (Malaysian Palm oil Information Series, 2005).

The Government of India in its X Five Year Plan (2002-2007), has proposed a target area of 50,000 hectare to be planted in Andhra Pradesh, Karnataka and Tamil Nadu with oil palm. The Government of India

visualizes a production of 2.64 iakh tonnes of crude palm oil by 2012 from an area of 1.65 lakh hectare oil palm (Abraham, 2004).

In 1960, the total planted area was 54,700 hectares and by 2003, this has been increased to 3.79 million hectares. The industry presently employs in excess of 3,00,000 workers and contributes more than 15 million ring git to the Malaysia economy (Malaysian Palm Oil Information Series, 2005).

Corley (2001), is of the view that in Indonesia, palm oil production increased progressively from 0.11 million tonnes in 1960 to 0.20 million tonnes in 1980 to 3.4 million tonnes in 1993 (project estimates were 2.12 million tonnes). It is proposed to be 7.4 million tonnes in AD 2000 and 12.29 million tonnes in AD 2010. Duke (2001) pointed that Nigeria, Ivory, Colombia, Thailand and Papua, New Guinea etc produce palm oil in significant quantities. By the next century, global production of the commodity is expected to be 19.9 million tonnes and Nigeria's contribution to be 1.01 million tonnes. The global average productivity in 1990 was 3.25 tonnes oil/ hectare/year and in Malaysia 3.81 tonnes oil/hectare/year. The average yield of Costa Rica was 3.13 tonnes oil/ hectare/year. Productivity elsewhere is less than the world average.

Nandhini and Archana (2004) opined that oil palm is a high potency crop and the future world demand for edible oil depends greatly on the growth of oil plantation. Its yield is 5 to 6 tonnes as compared to 1 to 2 tonnes of traditional oil seeds per hectare and so it is much cheaper than other edible oils.

The per-capita consumption of palm oil is unknown, but Americans consumed 68.5 pounds of fats and oils in the year 2000. About 40 per cent of

them are margarine and shortening, two major products containing palm oil. A crude approximation of worldwide per capita consumption is 8.7 pound / year, obtained by dividing the 61 billion pounds of annual palm oil production by the world population of about 6.3 billion people and assuming 10 per cent is used for non-food purposes (www.uga.edu/fruit/oilpalm.htm).

C-2. Dietary Uses

Palm oil is a natural food product which has been consumed for more than 5000 years – as cooking oil, a constituent of margarine and in shortening. It is also blended in a wide variety of food products. Modern oil extraction technology improves its quality and develops a variety of oils and palm oil products. Red palm oil is minimally processed palm oil that maintains the nutrient of β-carotene and vitamin E whereas refined, deodorized, and bleached palm oil (RBDPO) has these nutrients stripped from them, resulting in a clear oil. In its natural state, palm oil is red in colour due to a high concentration of carotene and tocols (www.tropicaltraditions.com/redpalm oil.htm).

Red palm oil possesses several characteristics that are important in determining its incorporation into food preparations and they are i) the high solid glyceride content giving the required consistency without hydrogenation. ii) resistant to oxidation and therefore has a long shelf life. iii) level of high melting point, triglyceride together with its relatively low solid content at 10°C helps in formulation of products with wide plastic ranges, which are suitable for hot climate and some industrial applications. iv) tendency to crystallize in small beta prime crystals, a property desirable for some application (eg. margarine and cake) and v) slow crystallization

properties, can lead to structural hardness in the finishing product and to a tendency for recrystallization (Ong and Goh, 2002).

About 90 per cent of the palm oil produced finds its way into food products, with industrial uses accounting for the remaining 10 per cent Red palm oil is used in a wide variety of foods for primary margarine, shortening and vegetable cooking oil. It is also used as a replacement for cocoa, butter and butter fat in ice cream and mayonnaise. Stability at the temperature used in deep frying is favourable to use quite often for fried foods (Corley and Tinker, 2003).

Judd (2002) attributed that Red palm oil has good oxidative stability due to the presence of natural anti-oxidants and absence of linolenic acid. It is comparatively cheap to use and produce fried food products with good flavour and long shelf life. It deteriorates less rapidly than other vegetable oils. However, on repeated frying, a brown colour is formed from minor phenolic components in palm oil products.

Thirumanidevi and Gayathri (2004) have indicated that Red palm oil is a cholesterol free, trans-free, non-genetically modified tasty alternative for cooking, baking and food preparations. In composition with several other vegetable oils, Red palm oil come out on top in terms of its phytonutrient content, its frying qualities and not lose its valuable phyto nutrients when it is heated.

Kameen (2004) points out that Red palm oil is an excellent general-purpose household cooking oil and very popular in many tropical and sub-tropical countries. It is extremely stable to high temperatures especially during frying and has a lesser tendency to smoke foam or form unhealthy

polymers. Since, oil itself is a blend, it helps to bring out aroma in foods cooked in it, thereby helping it to maintain a traditional taste. Red palm oil is also an excellent partner for blending with other vegetable fats and oils.

Matrade (2004) emphasized that Red palm oil is also most suited for the industrial frying purposes and is widely used for processing instant noodles, potato chips, French fries and doughnuts. It is also used extensively in fast food chain especially for fried chicken and snack items. During deep fat frying to prepare these foods, conditions such as time and temperature are involved. Under such conditions, unsaturated liquid oils are unstable, unless they are hydrogenated to enhance their oxidative stability. The use of Red palm oil is preferred because of its good physical properties and greater oxidative stability by virtue to its fatty acid composition and natural anti-oxidants. It is also very economical.

Red palm oil, today is a common ingredient in the ice cream industry. Milk fat, the traditional fat ingredient in ice cream is replaced by palm oil in combination with palm kernel oil. A smooth structured ice cream with excellent eating qualities is easily produced by this substitution. A fat blend comprising palm oil and other fats are used to replace milk fat in non-dietary creamers or coffee-whiteners. This also offers advantages in terms of product shelf life and convenience (Malaysian Palm oil Information Series, 2005).

Kalyanasundaram (2004) elucidated that Red palm oil is an ingredient for the manufacture of margarine. Its wide range of solid fat content, coupled with refiner's ability to produce different products makes Red palm oil, the most versatile raw material in margarine production units. Different

types of margarine like table margarine, cake margarine and pastry margarine are available in the market using Red palm oil, as an easily broken crumbly texture, which melts in the mouth to biscuits and pastry consistency and spread ability of fats are important when a soft smooth consistency is needed. Blends based on Red palm oil, hydrogenated palm oil or blends of palm stearin are widely used in the baking industry.

Palm-based shortenings are suitable for making breads, cakes, pastries, creams and other bakery products. No hydrogenation is required when palm oil or its products are used as the major ingredients in bakery products. The product range can be extracted further when palm oil is used in combination with palm oil different melting characterizes (Nutrition briefs, 2005).

Red palm oil helps to produce margarine that are naturally coloured. This is of special interest in India, where the artificial colouring of margarine is prohibited. These margarines are used at the table as well as in the baking industry (www.tropical traditions – natural palm oil, 2005).

Ong and Goh (2002) observed that Red palm oil is widely used as a bakery shortening, in confectioneries dairy products such as flavoured milk, ice cream and coffee whiteners. In some of these applications, it can be a substitute for cocoa, butter and saving the use of imported cocoa butter.

Red palm oil contains more antioxidants – beta carotene vitamin E than any other oil. It remains stable when used for cooking. It is not hydrogenated, is not processed with heat or solvents such as hexane and does not contain any trans-fatty acids (www. carotina-usa.com)

Vegetable ghee (Vanaspathi) is a very popular product in Asian countries. The product is meant to replace traditional "butter fat" based animal ghee. Red palm oil blended with other vegetable oils to produce vegetable ghee of excellent quality and texture. The use of palm oil in this product reduced the occurrence of trans-fatty acid, which have deleterious effects on human health (Ascherio and Willett, 1997).

Kalyanasundaram (2004) highlighted that by optimizing the fractionation conditions several grades of palm oil mid fraction with different solid-fat content and melting characteristics produced. These have applications in the confectionary industry in which they replace cocoa butter partially or wholly. These cocoa- butter replacers or substitutes are well accepted today, palm mid fractions are used on cocoa butter extenders or as the main component (50-70%) of cocoa butter. Two products based on hydrogenated palm oil have also been used as cocoa butter extenders.

Duke (2001) pointed out that Palm wine is made by tapping the male inflorescence of the oil palm and fermenting the resulting sap. Alternatively entire trees can be filled and the meristem tapped, which is often done where old plantations are being replanted. Palm wine has been an important part of West-African culture and is still made today in large quantities fetching good price.

The studies conducted by Nestel and Nalubola (2003) revealed that Red palm oil is technically feasible to add and use in fortified biscuits and other confectionary items and also acceptable to children. Parvati and Shailaja (1988) reported that Red palm oil was well accepted for shallow fat frying and seasoning. Manorama and Rukmini (1991) stated that

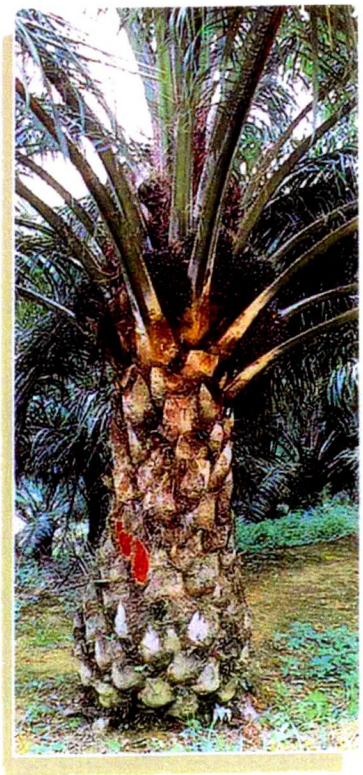
preparations made in 1:1 blend of refined groundnut oil and Red palm oil showed good cooking qualities.

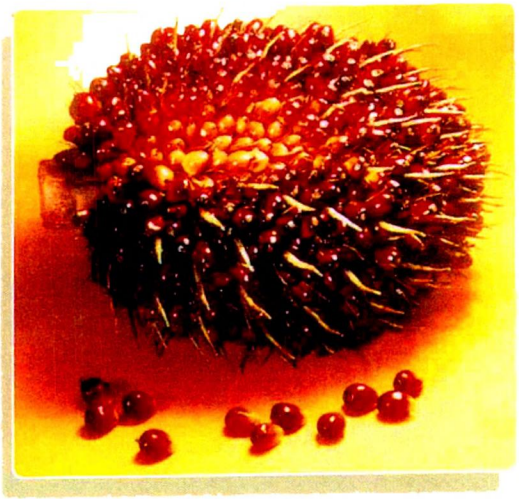
The main food uses of Red palm oil in Japan are in the production of margarine and shortening and as a deep-frying fat for the food manufacturing industry. For frying, both balm oil and palm olein are frequently blended with rice-bran oil or lard because the blend has strong stability against heat and oxidation and does not disturb the flavour of foods. As a result, manufacturers cater to customers' demand for any taste or flavour without compromising product stability. In China, most of the imported palm oil is used in food industry, especially production of deep fried instant foods, such as noodles, rice crusts and potato chips. Besides the large-scale production of convenience foods, preparation of the snack foods (both Western and Chinese style) vegetable oils are used and these oils are replaced using Red palm oil (Mori and Kaneda, 1997).

Red palm oil has a variety of applications as an additive in oil based food stuffs, a renewable energy source and its by products are put in to use by many industries. That is why it constitutes 33 per cent of the world's oil and fat export trade (Sundram, 2003).

C-3. Nutritional Significance

Significant progress in understanding the nutritional properties and health benefits of Red palm oil and its fractions has been achieved in recent years. This has been the result of more than 150 nutritional trials in both animals and human beings. The studies focused on understanding the effects of Red palm oil on coronary heart disease risk factors, physiological roles of its unique minor components etc. This has made Red palm oil, one of the





NUTRIENTS DENSE RED PALM OIL

most extensively researched oil in the world, today (Malaysian Palm Oil Information Series, 2005).

Both Red palm oil and palm kernel oil are derived from the fruits of palm trees. Palm kernel oil, which is produced from the kernel of the palm seed, is high in saturated fat and should be avoided, while Red palm oil is produced from the fleshy parts of the palm fruits and is rich in healthy polyunsaturated fats. As an added bonus, Red palm oil contains many phyto nutrients such as tocotrienol (the most powerful form of vitamin E) which lowers blood cholesterol level and helps to prevent heart diseases (www.health24.com/ dietnfood/general).

Cottrell (1991) stressed that Red palm oil is a minimally processed palm oil that naturally contains tocopherols and tocotrienols (Vitamin E) and carotenoids (Vitamin A) which gives the oil its red colour. It is produced from the fruit of the tropical palm tree Elaeis guineensis and has been used in food preparation as a nutritious source of oil in Asia and Africa.

Red palm oil contains a healthy mixture of all types of fatty acids; (polyunsaturated, monounsaturated and saturated fatty acids). The presence of high level of PUFA makes it nutritionally attractive. Red palm oil has different combination of fatty acids that is about 51 per cent unsaturated fatty acid equal proportion of saturated fatty acids. Saturated fatty acids are made up of 44 per cent palmitic acid and 5 per cent stearic acid. The unsaturated fatty acids consist of 39 per cent oleic acid (monounsaturated) and 10 per cent linoleic acid (polyunsaturated). The fatty acid composition is entirely different from the palm kernel oil. Red palm oil from the fruit of

palm is physically and chemically different from palm kernel oil, which is received from the seed (Nutrition briefs, 2004).

Palmitic acid, a 16-carbon chain saturated fat, makes up almost half of the fatty acids in Red palm oil. That means it is good for supplying energy and is easy to digest without putting a burden on insulin production and does not cause a rise in blood sugar (http://safarimkt.com/palm%20 oil/20benefit.htm)

According to Hornstra (2003) trans-fatty acid produced during hydrogenation of vegetable oils have consistently been reported to raise the atherogenic LDL-cholesterol level and reduce the HDL cholesterol level whereas red palm oil does not raise cholesterol in spite of containing on an average 44 per cent palmitic acid have also been extensively studied. The unique nutritional significance of Red Palm Oil are listed below:

- It contains nearly an equal proportion of oleic acid which is monounsaturated fatty acid that can prevent raise in blood cholesterol.
- It has about 10 per cent of PUFA offering some protection against hypercholesterolemia.
- It does not contain either cholesterol or trans-fatty acids, which are prone to raise blood cholesterol.
- Palmitic acid in Red palm oil does not raise blood cholesterol in an individual having normal blood cholesterol level.
- Tocophenols and tocotrienols, antioxidants against lipoprotein oxidation, which is considered to play a major role in causing Cardiovascular diseases.

- It is rich in β-carotene which can provide the much needed provitamin A in our diet which also serves as an antioxidant level. Thereby, Red palm oil serves as an ideal cooking oil for health benefits (Ong and Goh, 2002).

Judd (2002) documented that Red palm oil is the major source of the world's supply of oils and fats, but because of its relatively high content of saturated fatty acids (palmitic acid), its consumption has come under intense scouting. However, recent studies from human and animal experiments suggested that not all saturated fatty acids are cholesterol- raising. Palmitic acid appears to have no impact on the plasma cholesterol in normocholesterolimic subjects when dietary cholesterol intake is below a certain critical level (400mg/day). These differential effects of palmitic acid on plasma cholesterol are thought to reflect differences in LDLP – receptor status. Thus, Red palm oil is an inexpensive and readily metabolized source of dietary energy with minimal impact of cholesterol metabolism.

Bioavailability and vitamin A value of beta carotene from Red Palm Oil are assessed by an extrinsic isotope reference method. The research findings suggested that the bioavailability of beta carotene from Red palm oil is higher than other vegetable sources (You, 2001).

Angeles (2004) pointed that Red Palm oil is the least atherogenic oil compared to Refined bleached deodorized palm oil. The anti-atherogenic attributes of Red Palm Oil is due to the presence of abundant amounts of antioxidants, particularly the carotenoid and tocotrienol.

Red palm oil has a good mixture of antioxidants and together with its balanced composition of the different classes of fatty acids make the oil safe,

stable and versatile oil with many positive health and nutritional benefits (Chandrasekharan, 2000).

Edem (2002) observed that the unique characteristics of Red palm oil being its richness in both natural carotenoids and Vitamin E as tocopherol and tocotrienol. Red palm oil has higher bioavailability of antioxidant nutrients (proportion of nutrient that are used by the body) than other vegetable sources. It is particularly an important dietary oil for people who are not taking an excellent Vitamin E supplement.

Gopalan (1996) indicated that the bioavailability of its micronutrients is excellent as these fat-soluble vitamins are embedded in oil medium. One tablespoon of Red palm oil exceeds the recommended dietary allowances of beta-carotene-provitamin A and Vitamin E.

Awad and Frink (2000) stated that tocotrienols are super antioxidants of the Vitamin E family. Current research revealed that antioxidants fight against heart diseases, cancer and they even slow the aging process and also act as scavengers of damaging oxygen free radicals.

A diet rich in palm tocotrienol assist in dilating blood vessels and inhibiting human platelets from" striking one another, thereby potentially lowering the risk of a stroke or heart attack (Pruthi, 2001).

Red palm oil is particularly healthy because of its carotenoids and special forms of vitamin E in tocotrienols, a powerful form of vitamin E, which acts as a super antioxidant. The carotenoids in Red palm oil also act as antioxidants and one of these carotenoids namely lycopene, is associated with a reduced risk of certain types of cancer. Our body also needs

antioxidants to counteract so called"free radicals". Free radicals in the body are associated with degenerative diseases such as heart diseases and cancer, as well as general aging. It is therefore, essential to have a Red Palm Oil which is rich in antioxidants that will prevent the damage done to our body by free radicals (Awad and Frink, 2000).

The natural antioxidants of Red palm oil act as scavengers of oxygen free radicals and are believed to play a protective role in cellular aging, atherosclerosis, cancer, arthritis and Alzheimer's disease (Dickinson, 1997).

Red palm oil is considered to be the richest natural source of carotenoids with concentration of 700-1000ppm (You, 2001). It is 15 times richer in carotenes than carrots, 50 times richer than tomatoes. It is also the richest natural source of a powerful form of Vitamin E called tocotrienols. The bioavailability of these nutrients is excellent as these fat-soluble vitamins are embedded in the oil medium. Now people are conscious to understand vitamin E in palm tocotrienol which will help their day-to-day health and increase their longevity (Kameen 2004, Sivan *et al.* 2002 and Wagt, 2001).

The main component of carotenoids is beta-carotene, a precursor of Vitamin A and is a biological anti-oxidant. The normal process of refining Red palm oil removes the carotenoids from palm oil. However, Red palm oil products, which retain most of their original carotenoids, are now becoming more widely available (NFI, 1996).

Sivan *et al.* (2002) reported that Red palm oil contains high concentration of beta and alpha- carotene, which makes up approximately 90 per cent of its total carotenoid content. Importantly, Red palm oil is one of

the few excellent dietary sources of alpha-carotene, which has more powerful anti cancer effects than beta – carotene.

It is well recognized that the carotenoids are most stable and best absorbed in the presence of fat, which acts as the carrier. In addition to the beta-carotene, which accounts for 55 per cent of the carotenoids in Red palm oil, it contains several other carotenoids which have properties different from their provitamin A activity. Alpha-carotene, lycopene, phytoene and zeacarotenoids are the other major constituent of carotenoids in Red palm oil. All these carotenoids have shown impressive anti cancer properties and unlike synthetic beta-carotene supplements, Red palm oil contains a natural mix of many carotenoids (http://www.health24.com/dietnfood/general).

C-4. Health Benefits

Human feeding studies and epidemiological data have shown that Red palm oil do not raise blood cholesterol level in direct comparison with olive and peanut oil. Red palm oil enriched diet induced the highest level of protective high density lipoprotein (HDL) and the greatest production of liver low density lipo protein (LDLP) cholesterol receptors, key to removal of harmful LDLP cholesterol from the blood (www.ruchihealth.com).

Clinical human trials conducted by Ghafoorunissa (2003) showed that Red palm oil enriched diet do not raise blood cholesterol level in human beings compared with diets enriched either with saturated or unsaturated edible oils. On the contrary, Red palm oil diets are noted to increase high density lipoprotein (HDL) cholesterol and beneficially modulate the low density lipoprotein (LDL). High Density Lipoprotein (HDL) cholesterol ratio is protected against the onset of cardiovascular diseases.

Edem (2002) opined that diets containing 30 per cent of Red palm oil lower the total body weight when compared to 10 per cent Red palm oil supplemented diet. Increasing the Red palm oil content of the diet induced significant reduction in body and organ weight.

Red palm oil lowers the total blood cholesterol and bad LDL cholesterol and increases the good HDL cholesterol and also prevents the formation of thrombus in the blood vessels, i.e, it does not promote the formation of plagues in the arteries (Kameen, 2004 and Edem *et al.*, 2003). Human studies conducted in Europe, USA and Asia have confirmed that there is no significant rise in the total cholesterol when Red palm oil providing most of the dietary fat, is used as an alternative to other fats in the habitual diet (Punita and Chaturvedi, 2002).

Research carried out in other countries of the world as well as at NIN, Hyderabad during the last two decades has clearly established that Red palm oil unlike coconut oil, lard or hydrogenated oils, is not hypercholesterolemic when fed at level providing 30 per cent or more of energy in the diet of experimental and human volunteers. It has been clearly established that it is as safe as groundnut oil as adjudged by serum cholesterol level or blood clotting potential. The non-hypercholesterolemic property and nutritional safety of Red palm oil have been endorsed by nutritional food counts all over the world (Saxena, 2005).

Recent research has brought to light to feel that the people who substitute just five per cent of fat in their diet with Red Palm Oil lower their total cholesterol by nine per cent and their artery clogging LDL cholesterol

by 11 per cent – enough to slash their risk of heart disease. The credit goes to all the antioxidants present in the oil (www.medicalnews).

Preliminary studies at Michigan's Wayne State University (2004) showed that using Red palm oil reduces body fat by 27 per cent plus help to boost our ability to use sugar controlled insulin, two keys factors to keeping weight under control and delaying or even preventing the onset of diabetes.

Red palm oil at moderate level in the diet of experimental animals promoted efficient utilization of nutrients, favourable body weight gain, induction of hepatic drug metabolizing enzymes, adequate hemoglobinization of red cells and improvement of immune functions mainly due to its phyto nutrients. The consumption of moderate amount of Red palm oil reduces the level of oxidation and also reduces the health risk believed to be associated with the consumption of Red palm oil. Red Palm Oil, by virtue of its beta-carotene content, protect against vitamin A deficiency (VAD) and certain form of cancer (Edem, 2002). The study of Scrimshaw (2000) recommended that Red palm oil used as a salad and cooking oil or as blends with other vegetable oil is a sustainable dietary approach to the prevention of sub-clinical Vitamin A deficiency (VAD).

A two-year research study in Canada found a clear increase in serum vitamin A level among mothers and children when they were fed with Red palm oil regularly. The oil was integrated in National program for the prevention of VAD and extended to other areas of the North Central Africa, South of the Sahara Desert to improve serum vitamin A status of the vulnerable groups (Public Health Nutrition, 2004).

Red palm oil supplementation have shown to significantly reduce the prevalence and grade of anemia among vulnerable groups especially in expectant mothers and adolescent girls (Radhika, 2003).

Vitamin A can be produced within the body from certain carotenoids notably betacarotene, scientists believed that because of its high carotenoid content. The immune system function is enhanced and protected against Vitamin A deficiency and certain forms of cancer Carotenoids are most stable and best absorbed in the presence of fat, which acts as a carrier (www. smartpublications.com).

Ostuland (2002) considered that Red palm oil as a major source of carotenoids which can effectively inhibit some types of cancer. A diet containing Red palm oil, compared to diets based on other oils will provide the same amount of calories, exerted an inhibitory effect on the development and incidence of experimentally induced breast cancer. It has been shown that tocotrienol present in Red palm oil inhibit the growth of cancer cells in vivo as well as in vitro.

Canfield (2000) opined that Red palm oil in the maternal diet increases provitamin A-carotenoid in breast milk and serum of the mother and infant. Red Palm oil consumption increased serum antioxidants concentration and improved iron absorption of anemic adolescent girls (Manorama, 1997).

A study by Edem *et al.* (2003) in rats revealed that moderate consumption of Red palm oil helps to support growth and normal development of animals and is also protective against certain derailment in metabolism.

A tablespoon of Red palm oil contains 10,000 IU of immunity – boosting vitamin A- enough to slash a woman's risk of cold and flue 67 per cent. According to an Harvard research, people who enjoy vitamin A rich diets also enjoy 70 per cent lower risk of all type of cancer. Red palm oil antioxidants slow the cellular aging that often leads to cancerous changes (Angeles, 2004).

Scientific studies conducted at the Universities of Louisiana and Wisconsin in the USA, the University of Reading in the UK and the Universities of Western Ontario in Canada (1997) have identified the following health benefits of Red palm oil:

- a reduction in the incidence of arterosclerosis, which can result in heart diseases.
- a reduction in blood cholesterol level.
- a reduction in blood clotting, combined with blood vessel dilation, thus preventing heart attack and stroke.
- Inhibition of the growth of breast cancer cells, which suggests that Red palm oil acts as a chemo preventive agent.

Zhang *et al.* (2003) stated that Red palm oil is a good source of carotenoids and vitamin E, when used in Chinese diet preparations and it can significantly increase plasma concentration of alpha carotene, beta carotene, lycophene and alpha tocopherol.

Kameen (2004) attributed that palm tocotrienols play a major role in cancer prevention and treatment. Only second to heart diseases, breast cancer is the leading cause of death in women, today. Valuable tocotrienols and carotenoids extracted from Red palm oil used, supplements for the

prevention of heart diseases and breast cancer. Incorporation of Red palm oil in our diet, is a way to get these health benefits.

Zhang *et al.* (2003) confirmed that Red palm oil contains tocols that act as the natural biological antioxidants. Tocols have a number of health promoting biological functions. Together with carotenoids, they act as antioxidants to protect tissues and membranes from free radical damage and to prevent lung and oral cancer and the damaging effects of environmental toxins. The tocotrienol in Red palm oil have beneficial effects on blood cholesterol and platelet aggregation.

Caroll *et al.* (1995) pointed out the gamma tocotrienol is three times potent in stopping growth of human breast cancer cultured cells than tomoxiten (a widely used drug in treatment of breast cancer). When used together with tomoxiten, it was found to be 45 times more potent. It is also highlightened that Red palm oil rich in vitamin E, suppress the synthesis of cholesterol in liver and lowers blood cholesterol level.

Recently palm tocotrienols have been found to have several medical uses and combat heart diseases, lower bad cholesterol levels, neutralize free radicals and even fight against cancer cells. Together with carotenoids, they act as antioxidants to protect tissues and membranes from free radical damage and to prevent lung and oral cancer and its damaging effects of environmental toxins (Zhang *et al.*, 2003).

Sundram *et al.* (2003) opined that vitamin E reduced LDL cholesterol and triglycerides, raise good HDL cholesterol, thereby reduce the risk of heart attack and lowers the risk of developing cataract. The vitamin E in Red palm oil inhibits human platelets from sticking to each other. Red palm oil in

diet increases production of prostacylin (hormones that prevents blood clotting) and also decreases the formation of blood clotting hormone (Thromboxane).

Tocotrienol have been found to significantly inhibit HMG-CoA reductase (the enzyme that controls the rate at which cholesterol is synthesized) which ultimately results in lowered serum cholesterol (Wood *et al.*, 1991).

C-5. Effect of Supplementation of Red palm Oil on Nutritional Status with Special reference to Vitamin A Status of Young Children

The countries of South Asia are blessed with a wide array of inexpense foods rich in vitamin A carotenoids. There have been many studies examining the possibility of using foods naturally rich in vitamin A or provitamin A to combat vitamin A deficiency in developing countries (Gopalan, 1998). Red Palm oil is one of the natural richest sources of beta carotene, widely grown in Malaysia, India, Indonesia, Brazil and Parts of East Africa (May, 1994) and Rukmini (2000).

The study conducted by Shuijvenberg (2001) in India have shown that administration of a tablespoon of RPO (5g) daily for 21 days was sufficient to protect the child at risk from blindness for the next six months. This study also suggested that provitamin A – carotenoid in RPO are absorbed, stored and slowly converted to the active retinal equivalents at the demand of the child's metabolic needs.

A small intake of 3-5 grams of Red palm oil daily is sufficient to meet vitamin A needs of the population. Red palm oil is therefore, a

promising alternative in any strategies for combating vitamin A deficiency (Roy, 2001).

Studies conducted by Manorama (1996) confirmed that supplementation of sweet snack with Red palm oil (provided 0.24mg beta carotene for 60 days) was effective in improving vitamin A of school children as a daily dose of 600ηg synthetic vitamin A.

A study by NIN showed that carotene of Red palm oil supplementation significantly improved the serum retinol and haemoglobin of rural preschool children under the age of five (Nugyen, 2001).

A number of pre 1990 human feeding studies conducted by Anderson *et al.* (1986) and Mattison and Grundy (1985) reported that Red palm oil diets showed a reduction of blood cholesterol values ranging from seven per cent to 38 per cent.

The findings of Jayakumar (2001) have shown that Indian school children who are fed with supplementary snacks, prepared with three grams of Red palm oil for 60 days showed a significant increase in serum retinol level, almost two folds.

Devadas and Chandrasekhar (1996) and Sivan *et al.* (2002) reported that pre-school children per capita consumption of five millilitre of Red palm oil daily for 10 months in feeding program in Tamil Nadu has shown to be an effective in improving the vitamin A status of children and women. In this study, daily afternoon meal containing Red palm oil was well accepted and improved the Vitamin A status of preschool children, the disappearance rate of Bitot's spots and the level of blood beta carotene were

higher and the incidence rate of new Bitot's spot was lower in children consuming the Red palm oil meal.

Similarly consumption of 1.8 to 7.8 mg β carotene as Red palm oil was found to be as effective as synthetic vitamin A (Nestel and Nalubola, 2003).

Study conducted by Vaidehi and Vijayalakshmi (1993) recommended the products prepared by Red palm oil in supplementary feeding and prophylatic programme to control Vitamin A Deficiency.

Beta carotene rich Red palm oil incorporated diet was provided as supplement to 409 school children for 10 months to study their β carotene level. The results indicated that improved consumption of Red palm oil enhanced Beta carotene level and reduced the occurrence of Bitot's spots among the experimental group of school children (Jayakumar, 2001).

According to Gopalan (1998) a small quantity of 2-3 grams of Red palm oil per day consumed will easily meet the deficit in the vitamin A intake of preschool children, for one gram of Red palm oil supplies 200-400μg of beta-carotene.

Studies in India have shown that a table-spoon of Red palm oil about 3-5 g/day and administered for 30 days was sufficient to protect school children at risk from blindness and to meet the vitamin A needs of the population. Red palm oil, is therefore a promising alternative in any strategy for combating vitamin A deficiency (Saxena, 2005).