SHELF LIFE STUDIES ON RED PALM OIL

By

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CERTIFICATE

Certified that this thesis entitled '**Shelf life studies on red palm oil**' is a record of research work done independently by **Miss. Archana. U.** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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I hereby declare that this thesis entitled **'Shelf life studies on red palm oil'** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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Introduction

INTRODUCTION

Fats and oils are important dietary components for humans. They are excellent sources of energy and fat soluble vitamins 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.

Cooking oils differ in their nutritional importance based on their composition especially the fatty acid content. Commonly consumed vegetable oils like groundnut, safflower, sunflower and sesame oils are rich in polyunsaturated fatty acids (PUFA) where as animal fats like lard and butter are rich in saturated fatty acids (SFA).

Oil palm is a high potency crop and the future world demand for edible oil depends greatly on the growth of oil palm plantations (Plate 1). Oil palm is the second largest source of vegetable oil in the world (Arumughan *et al*., 1995). It yields about 22 tonnes of fresh fruit bunch per hectare (Plate 2). Cultivation of oil palm was started in India by

PLATE-1 **Oil palm bearing mature fruits**

PLATE-2 **A fresh fruit bunch**

Oil Palm India Limited under the Technology Mission on Oilseeds (TMO) which was set up in the year 1986 to meet the vegetable oil shortage in India.

Red palm oil (RPO) is unique in its physico-chemical properties that characterise it as an edible oil. It was considered to contain a better proportion of fatty acids, the predominant fatty acids being palmitic acid and oleic acids. It was declared as non-hypercholesterolemic (Ng *et al*., 1991) and thus is beneficial in reducing cardiovascular risk.

RPO is a very rich source of β-carotene which is an important source of vitamin A. It is also a natural source of vitamin E, the tocopherols and tocotrienols, which act as natural antioxidants. Scavenging the free radicals seem to play a protective role against cellular aging, atherosclerosis and cancer.

The ideal fatty acid composition and the presence of carotenoids and tocopherols makes RPO as a valuable dietary oil. Nutritional biochemical and toxicological studies on RPO conducted at National Institute of Nutrition (NIN) revealed that RPO was found to be nutritionally adequate and toxicologically safe for human consumption.

Palm oil can be used as a cooking oil, shortening and margarine. It is resistant to oxidation and therefore has a good shelf life, is suitable for hot climates and possesses properties that are desirable in cakes and other bakery products. It was found that the oil quality deteriorates when stored. A survey of literature clearly indicated that there are a very few attempts made to study the efficacy of various containers which can be used for proper storage of unrefined red palm oil (Thomas, 1998).

So this study is an attempt to ascertain the changes of RPO during storage in different containers.

The specific objectives of the study include the following.

1. To determine the physical characteristics like specific gravity, moisture and smoke point.

2. To determine the chemical characteristics like acid value, iodine value, peroxide value, free fatty acid content, fatty acid composition, β-carotene and vitamin E.

3. Product development using the RPO and assessment of organoleptic qualities of the product developed.

REVIEW OF LITERATURE

The available literature on the study entitled "Shelf life studies on Red Palm Oil" was pursued and reviewed under the following headings.

2.1 Red palm oil - composition and quality

2.2 Fatty acid composition of red palm oil

2.3 Carotenoids in RPO

2.4 Tocopherols and tocotrienols in RPO

2.5 Stability of RPO upon heating and processing

2.6 Storage stability of RPO

2.7 Food uses of palm oil

2.8 Acceptability of RPO in food preparations

2.9 Studies on supplementation trials with RPO to combat vitamin A deficiency

2.10 Therapeutic uses of red palm oil

2.1 Red palm oil - composition and quality

Red palm oil (RPO) is extracted from the mesocarp of the fruit of the oil palm (*Elaeis guineensis*). Dura, pisifera and tenera are three varieties of oil palm. In dura variety the mesocarp content is low with a thick shell (Plate 3) and in pisifera variety the kernel may be pea shaped with high mesocarp content (Plate 4). The commercially cultivated

PLATE 3 Cross section of a dura fruit

PLATE 4 Cross section of a pisifera fruit


pisifera

variety is tenera which is an hybrid of dura and pisifera (Plate 5). According to Ng and Tan (1988) RPO is the unrefined, unbleached, thick, orange coloured oil extracted from the oil palm fruit with its carotenoid content intact (Plate 6).

Red palm oil is a highly viscous semi solid fat and is orange-red in colour. NKPa *et al*. (1990) observed that the iodine value and slip melting point of RPO may range from 45-56 and 31-38°C respectively.

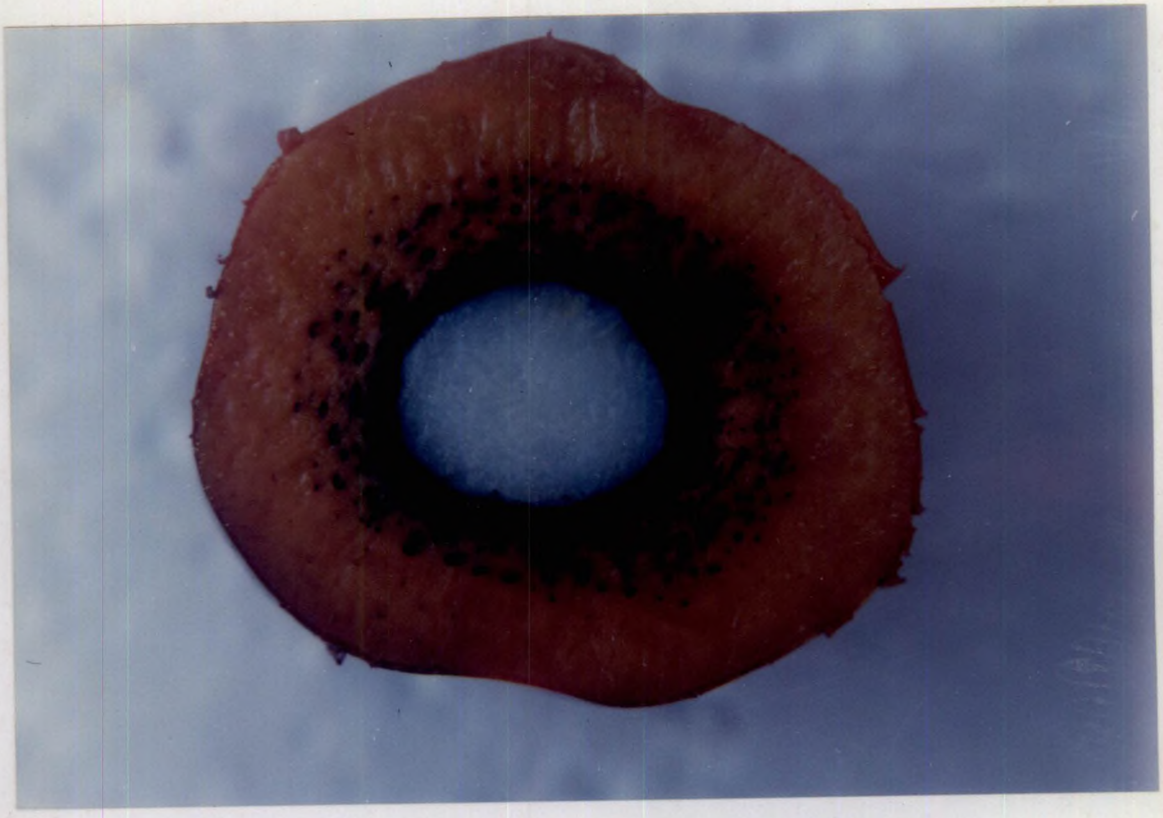
Chan (1983) reported that palm oil contains two fractions, the stearin and palmolein fraction. The stearin fraction contains more saturated fatty acids and is solid at normal temperature, while palmolein has more unsaturated fatty acids and is liquid at normal temperature.

According to Arumughan *et al*. (1989) red palm oil 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 (0.5 ppm).

Congopalm (1970), Itoh *et al*. (1973), Jacobsberg (1974), Meara and Weir (1975), Gee (1984) and Goh *et al*. (1985) reported that the non-glyceride materials also called unsaponifiable matter (0.5 per cent), include carotenoids,

PLATE 5 Cross section of a tenera fruit

PLATE 6 Freshly extracted red palm oil




RAW PALMOIL

tocopherols and phospholipids (0.2-5 ppm). It also contains sterols (0.03 per cent) such as ß - Sitosterol, stigma sterol, campesterol, cholesterol (0.01 per cent), squalene (200-500 ppm), methyl sterols (40-80 ppm) and dimethyl sterols (40-80 ppm), sesquiterpene and diterpene hydrocarbons (30 ppm), aliphatic hydrocarbons (50 ppm), aliphatic alcohols (160 ppm), methyl esters (50 ppm), ketones (trace) and waxes (trace).

2.2 Fatty acid composition of red palm oil

According to Chan (1983) palm oil consists of largely triglycerides which are esters of glycerol with fatty acids. The fatty acids are straight chained with usually even number of carbon atoms and are saturated or unsaturated in C-C linkage. Palm oil contains about 40 per cent each of palmitic acid and monounsaturated oleic acid with about 10 per cent diunsaturated linoleic acid, 5 per cent stearic acids like lauric, myristic, palmitoleic and arachidic acid (Tan and Flingoh, 1981).

The fatty acid composition of RPO as analysed at Malaysian Agricultural Research and Deret Institute (MARDI), Palm Oil Research Institute of Malaysia (PORIM), Regional Research Laboratory (RRL), Thiruvananthapuram and National Institute of Nutrition (NIN), Hyderabad is presented in Table 1.

Table 1 Fatty acid composition of RPO from different sources (in percentage)

Fatty acid		Source			
		MARDI[1]	PORIM[2]	RRL[3]	NIN[4]
Lauric	C 12:0	0.1	0.2	-	-
Myristic	C 14:0	1.0	1.1	1.2	0.8
Palmitic	C 16:0	43.7	44.0	42.44	42.0
Palmitoleic	C 16:1	0.1	0.1	-	-
Stearic	C 18:0	4.4	4.5	5.17	5.1
Oleic	C 18:1	39.9	39.2	37.01	42.1
Linoleic	C 18:2	10.3	10.1	11.71	10.0
Linolenic	C 18:3	-	0.4	-	-
Arachidonic	C 20:3	0.3	0.4	-	-
Iodine value	(Wij's)	52.9	52.3	52.0	47.13
Slip melting point	(°C)	34.2	36.0	36.0	37.0

Source: 1 and 2 Tan and Oh, 1981
3 Arumughan *et al*., 1989
4 Manorama, 1992

Manorama and Rukmini (1989) stated that the physico-chemical parameters and fatty acid composition of crude palm oil and raw palm oil indicated that crude palm oil has higher levels of (a) free fatty acid (b) unsaponifiable fraction and lower iodine value than RPO. Fatty acid composition indicated that both have similar values of palmitic acid (42 per cent) and linoleic acid (10 per cent).

According to Wong (1981) palm oil has an average free fatty acid of 3.66 per cent.

Grut (1966) reported that during storage frequent and excessive heating lead to an increase in free fatty acid.

2.3 Carotenoids in red palm oil

Carotenoids are present in traces in many vegetable oils but are usually high in RPO (Tan *et al*., 1986 and Manorama and Rukmini, 1987). Carotenoids are a group of lipid-soluble hydrocarbons that are widely distributed in plant world. Carotenoids in general are used as food colourants.

The main forms of carotenoids are x, ß, r and o forms. Of all the forms, β carotene is the most active form. The carotenoid content of RPO from Malaysia and Republic of Zaire was found to vary between 500 and 700 ppm (Clegg, 1973). Larger amounts (800-1600 ppm) have been reported from Nigeria, Togo, Cote'd'Ivoire and Dahomey (Ames *et al*., 1960). The geographic variations in carotenoid content of RPO are presented in Table 2.

Table 2 Geographic variation in carotenoid content of RPO

Country of origin	Carotenoids (ppm)
Plantation oils	
Malaysia	500 - 700
Indonesia	400 - 600
Zaire	500 - 700
Cote'd'Ivoire	390 - 610
Plam grove oils	
Nigeria	800 -1600
Cote'd'Ivoire	790 -1480
Togo	1310 -1480
Dahomey	910 -1520

Goodman (1984) reported that carotenes are long - chain, conjugated unsaturated hydro-carbons, while xanthophylls are oxygenated carotenes.

According to Unnithan (1996) RPO is a fully refined edible oil rich in natural carotenoids and vitamin E. Crude palm oil is the richest natural plant source of carotenoids interms of retinol (Provitamin A) equivalents. It contains about 500-700 ppm carotenes and about 1000 ppm of vitamin E. Conventional refining techniques destroy 100 per cent of the carotenes.

Ooi *et al.* (1985) indicated that among the edible oils, palm oil has the highest concentration of carotenoids of which alpha and beta carotenes constitute about 90 per cent. It is a rich source of provitamin A and can be supplemented for vitamin A deficiency diet.

According to Brubacher (1968) the carotenoid content of the oil varies depending on the degree of ripeness and the genotype of the fruit from which it is extracted. Carotenoid content also varies with the country of origin of the oil.

A typical analysis of the composition of carotenoids shown that alpha and beta carotenes are the major components and the rest are gamma carotene, lycopene and xanthophylls. The composition of palm oil carotenoids are given in Table 3.

Table 3 Carotenoid composition

Carotenoids	Percentage of total			
	Zaire	Rep. of Benin	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

Brubacher (1968) observed that both alpha and beta carotene possess provitamin A activity; 1 ug of β carotene is equivalent to 1.66 IU of vitamin A, 1 ug of α carotene to 0.9 IU of vitamin A. Palm oil is therefore a rich source of vitamin A.

According to Hassan (1987) in the refined palm oil, all the components except carotenoids are present. The carotenoids are generally removed or destroyed while refining.

Manorama (1992) reported that RPO is nutritionally superior to Refind Bleached Deodourised Pal Oil (RBDPO) since it is rich in β - carotene when it is cooked, 70 to 88 per cent of its β - carotene has been found to be retained.

Hume and Krebs (1979) stated that bioavailability of β - carotene from vegetables and carrots was only a third of that of β - carotene in oil. Since RPO is a fat in which β - carotene is naturally present, it appears to be more bioavailable.

2.4 Tocopherols and Tocotrienols in RPO

All vegetable oils contain high amounts of tocopherols and the amount increases with increase in unsaturation of the oil. Palm oil is unique in that in addition to tocopherols it has high amounts of tocotrienols (Tan and Khor, 1989). The normal range present in RPO is

600 to 1000 ppm, and the level is generally reduced in the refining process to about 50-80 per cent (Tan *et al.*, 1991). Palm oil contains both Tocopherols (T) as well as tocotrienols (T3) which are the unsaturated analogues of tocopherols (Nesarethnam *et al.*, 1987).

Bauernfeind (1974), Jacobsberg *et al.* (1978) and Gapor and Ong (1982) observed that both tocopherols and tocotrienols occur in x, B, r and o forms. MacLellan (1983) reported that 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. They act as powerful antioxidants and help to reduce cellular damage due to free radicals that may arise from the body's normal oxidative energy metabolism or in our environment. Of all the forms a tocopherols has the highest vitamin E activity for animals and man.

RPO is unique in its tocopherol content in that it is abundant in tocotrienols which are lacking in most of the other vegetable oils (Table 4). They have a protective effect on platelet aggregation (Hornstra, 1988) and tumour progression (Sundram, 1989), thus suggesting medical implications.

Table 4 Total tocopherol (T) and tocotrienol (T3) levels in oils

Oils	T (ppm)					T3 (ppm)					Total T+T3 (ppm)
	α	β	γ	δ	%	α	β	γ	δ	%	
Palm oil	256	-	316	70	55	143	32	286	69	45	1172
Soyabean oil	101	-	593	264	100	-	-	-	-	-	958
Safflower oil	387	-	174	240	100	-	-	-	-	-	801
Cotton seed oil	389	-	387	-	100	-	-	-	-	-	776
Sunflower oil	599	15	38	7	96	25	-	-	-	4	684
Groundnut oil	139	3	189	18	100	-	-	-	-	-	349
Coconut oil	5	-	-	6	31	5	1	19	-	69	36

Source: Tan and Khor, 1989

2.5 Stability of RPO upon processing and heating

RPO, like any other vegetable oil, should be subjected to refining process to remove undesirable materials such as colour pigments, oxidative components, gums, metal contaminants and volatile compounds. According to Arumughan *et al.* (1989) during this refining process, nearly all carotenes and considerable amounts of tocopherols are lost. Goh *et al*. (1985) observed 15.5 per cent loss of tocopherol during steam deodorization and distillation of free fatty acids in case of RPO.

The studies conducted by Pereira *et al*. (1991) proved that RBD palm oil has a better oxidative stability than olive oil, soya bean and sunflower oils as a frying medium. Myricetin was found to be a good antioxidant for the inhibition of lipid peroxidation when fats and oils are heated at higher temperatures.

According to Hussain (1991) when crude palm oil is heated, the components undergo several oxidative and thermal reaction which ultimately change the physical, chemical, physio chemical, physiological, nutritional and sensory properties of oil. Graf (1976) reported that the colour of palm oil can be reduced to acceptable levels and good quality. Oil can be heat treated to yield an almost white oil.

Okiy and Oke (1986) reported that repeated heating of crude palm oil (CPO) results in oxidation of its components and fragmentation to various compounds which alter the organoleptic, chemical and physical properties of oil.

Parvatham *et al*. (1994) observed that the viscous, orange-red coloured crude palm oil was darkened and loosened in consistancy during heating. Refined palm oil which was light yellow in colour slightly changed to dark yellow in colour after two hours, four hours and six hours of heating. Smoke point of crude and refined palm oil decreased when heated for two hours, four hours and six hours. The decrease in smoke point of heated samples is due to an increase in concentration of free fatty acid and on repeated heating.

In Business Times (1990) it has been reported that palm oil is one of the best frying fats. Due to the absence of linolenic acid, it does not leave unpleasant room colour.

Augustin *et al.* (1987) found that the decrease in smoke point is regarded to be primarily a consequence of the increase in acidity.

Wong (1977) identified some stable yellow pigments of heated palm oil which are difficult to bleach and reported them to be co-oxidation products of carotene and linoleate residues. Since the concentration of carotenes is high in CPO, it was assumed that the concentrations of the breakdown products of carotenes will be more than those of linoleic acid in the oxidised samples of CPO.

According to Parvatham *et al.* (1994) the free fatty acid content of both the oils increased with the number of hours of heating. The iodine value of crude and refined palm oil showed a decrease which measures the overall deterioration of oils during heating. It was also found that the increase in peroxide value was more in refined palm oil than in CPO. The total tocopherol content was higher in CPO when compared to that of refined palm oil.

Normally refined palm oil and palm oil treated thermally were compared by Lang *et al*. (1966) in order to destroy carotenoids in long term experiments with rats. No toxic effects were observed. However in this study palm oil was not compared with oils or fats.

Manorama and Rukmini (1991) studied the effect of different cooking methods like baking, seasoning, deep frying and shallow frying on retension of B - carotene and observed that 70-88 per cent of it was retained in the cooked foods. Repeated deep frying using the oil five times consecutively, resulted in a total loss of β - carotene by the fourth frying stage itself and alteration of its organoleptic, physical and chemical properties. Hence, CPO may be suitable for single frying operations only or for preparations which involve a short heating time and completely take up the oil into the cooked product like cake, upma, kichidi and suji halwa. The authors also reported a decrease in carotene content on heating. Repeated heating of RPO resulted in a steep fall of carotene content with each consecutive frying. They observed that the loss of β - carotene during deep frying was attributed to two factors, namely (a) loss due to the incorporation into the food stuff being fried (b) loss due to heat deterioration.

They also estimated the retension of β - carotene in different cooked foods after preparation and uniform homogenisation of the food item and extraction of carotenoids from an aliquot for injection and separation on HPLC. It was observed that total carotene retension ranged from 69 to 86 per cent and β - carotene retension from 70 to 80 per cent. Cake baked at 220°C for 45 minute retained 88 per cent of the β - carotene originally present when compared with other food items which are cooked at 180°C since CPO is thoroughly blended with other ingredients like flour, sugar and egg thereby avoiding direct exposure to heat.

2.6 Storage stability of RPO

Storage of oils bring about certain changes in their physico-chemical constituents, 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 and Murthi *et al*., 1987).

According to Sarojini and Bhavani (1997) colour, viscosity and refractive index of RPO as well as those of oil blends did not show any changes upon storage. FFA levels in the CRPO was slightly high initially (4.52) and it further increased upon storage (5.10) which could be due to presence of moisture in the oil. Other chemical characteristics like iodine value and saponification value did not show significant variations on storage. An increase in peroxide value in CRPO as well as in the blends on six months storage by 4 to 4.2 units from an initial value of 2.4 to 2.5 units was found.

A study by Ukhun (1986) showed that on storage, the iodine value of RPO increased with increase in water activity. Chang and Ong (1987) proved that water activity of 0.94 at 50°C or 0.19 per cent moisture was the ideal condition for storage of RPO.

NKPa *et al*. (1990) found that RPO packaged in plastics and clear glass bottles recorded higher hydrolytic and oxidative deterioration as judged by free fatty acid, peroxide value and acid value. Lacquered metal cans, green glass bottles and amber glass bottles showed lesser oxidation values.

According to Parvatham (1995) on keeping, oil made up of unsaturated fatty acids are subjected to oxidation and hydrolysis at various rates. Light, moisture, oxygen and heat are some of the environmental factors that affect the stability of oils.

Moolayil (1983) reported that palm oil, whether in crude or in processed form has excellent keeping qualities.

2.7 Food uses of palm oil

Rao (1987) and Anonymous (1988) reported that palm oil lends itself to a wide range of food uses both in the domestic kitchen and in the food industry.

According to Berger (1992) and Wenxun and Xiaoshu (1994) palm oil, with its moderate linoleic acid content, very small linolenic acid content and high level of natural antioxidants, is suitable for direct use in most frying applications and this is a major use world wide. For the large scale frying of potato crisps, palmolein or a blend of palmolein with soya or rapeseed oil is preferred (Lin, 1991).

Uragami *et al*. (1986) observed that palm oil contains both 2-oleoyl 1, 3-dipalmitin (POP) and 2-oleoyl 1,3-distearin (SOS) which are the major components of triglycerides of cocoa butter and has a tendency to polymorphism. They can therefore be used in any ratio with coco butter. Texturised palm oil as such or in blends is an ideal fat for short pestry and biscuits (Berger, 1992).

According to Ministry of Agriculture, Forestry and Fishery (1991) the main uses of palm oil in Japan are in the production of margarine and shortening and as a deep frying fat for the food manufacturing industry.

Palm oil is used to manufacture margarine and shortening because of its physical characteristics, bland taste and free from cholesterol.

Rao (1994) indicated that palm oil does not undergo much oxidative damage at a temperature of 180°C, unlike other vegetable oils with a high linoleic acid content. It has certain advantages for the production of vanaspati since it does not need hydrogenation. Palm oil with B - carotene can help to produce margarines that are naturally coloured.

According to Kee (1969) palm oil is suitable for the manufacture of margarine because of its low tendency to turn rancid and therefore ensuring longer shelf life.

Tang *et al*. (1983) reported that palm oil and its products do contribute to softening of the consistency of vanaspati as well as to promote oil separation.

According to Idris (1995) cakes prepared with palm oil in combination with butter fat had better baking properties than those made with pure butter fat and at the same time had the desired buttery flavour.

2.8 Acceptability of RPO in food preparation

Sensory evaluation of Indian foods prepared with the oil have shown that RPO was well accepted and can be used in supplementary feeding programmes in pre school children (Manorama, 1992).

Easwaran 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.

Manorama and Rukmini (1992) and Rukmini and Manorama (1993) conducted acceptability studies with recipes made using RPO. RPO was found to be well accepted in preparations where its yellow or orange colour blended well with the natural colour of certain food items like upma, vegetable curries, tamarind rice, deep fried products and cake. However, the odour of RPO lingered behind as an after-taste a few minutes after consumption. It was also observed that a blend of 1:1 RPO and GNO (groundnut oil) was better accepted.

The field trials showed that RPO is highly acceptable and it is feasible to promote its consumption in feeding programmes as well as at the house hold level (Anon, 1996).

2.9 Studies on supplementation trials with RPO to combat vitamin A deficiency

Vitamin A deficiency has currently been recognised as one of the most important of the three commonly occurring micronutrient deficiencies of public health significance, leading to irreversible blindness in young children (Vijayaraghavan, 1997). Tandon *et al*. (1981) and NNMB (1991) reported that in India, milder forms affecting conjuctiva. Bitot spots are observed about 1-5 per cent in pre-school children (1-5 years). There exists a considerable variation in the extent of vitamin A deficiencies between the States. Longitudinal community studies revealed that in some parts of the country, the incidence of corneal xerophthalmia is between 0.5 to 1 per 100 pre school children (Vijayaraghavan *et al.*, 1990).

Reddy (1991) observed that RPO is one of the richest natural sources of carotenes and could serve as an excellent vehicle for vitamin A supplementation which has been reported to have beneficial effects in reducing child mortality and morbidity.

The efficiency of dispersion and absorption of vitamin A and β - carotene is affected by the presence or absence of many factors, among which fat in the diet is of atmost importance (Hollander, 1981). Fat provides the vehicle for transporting Vitamin A and carotenoids from the stomach into the intestinal lumen, and is also the source of some of the digestion products which interact with bile salts and micelles and solubilize the vitamins. Manorama *et al.* (1977) reported that RPO which is a source of carotenoids in a fat medium, seems to serve as an ideal vehicle by simultaneously increasing the fat as well as pro-vitamin A intake. This probably explains the high efficiency of conversion of β - carotene to vitamin A.

Beaton *et al.* (1993) indicated that when massive doses of vitamin A are administered once in six months, they afford protection till the next dose is given, because of the capability of the liver to store in the form of retinyl esters and release them as retinol bound to RBP when need arises.

The results of the study conducted by Manorama *et al*. (1997) indicated the possibility that RPO is able to afford similar protection at the end of six months of non supplementation.

Multicentric trials in Kerala, Tamil Nadu and Delhi revealed that consumption of RPO in small quantities resulted in a significant improvement in vitamin A status (Seshadri, 1996).

Rukmini (1994) reported that Indian school children fed supplementary snacks prepared with RPO for 60 days had significant increase in serum retinol levels as well as an increased liver retinol store suggesting the ready bioavail-ability of β - carotene and a good source of provitamin A for combating Vitamin A deficiency.

Some products like nutritious biscuits, imitation cheese and supplementary snacks were prepared by Thomas (1998). 20 per cent of the hydrogenated fat for the preparation of biscuits was replaced by red palm oil. The biscuits had a shelf life of 30 days. The processed imitation cheese at 3 per cent level was most acceptable and comparable in terms of texture, appearance, taste and flavour to a sample made with toned milk. The supplementary snacks were prepared substituting the fat with a blend of 1:1 of red palm oil and groundnut oil.

2.10 Therapeutic uses of red palm oil

Palm oil has several nutritional benefits. Ghafoorunissa (1993) reported that the use of palmolein along with any other vegetable oil will favourably shift the dietary PUFA/SFA and linoleic or α - linolenic acid (n-6/n-3) ratios closer to the recommended range and thus provide an additional advantage because of the hypocholesterolemic antithrombotic properties of tocotrienols.

Arens *et al*. (1957), Anderson *et al*. (1976), Baudet *et al*. (1984), Grundy (1986), Hornstra (1986), Hornstra (1988), Cottrell (1991), Chong, Y.H. (1991), Kritchevsky (1991), Kritchevsky *et al*. (1992) and Rukmini and Manorama (1993) found that RPO not only reduced blood cholesterol but also demonstrated an antithrombotic effect. The tocotrienols present in palm oil are known to reduce circulating cholesterol concentrations in humans (Anon, 1987; Hornstra *et al*., 1987; Qureshi, 1991 and Tan *et al*., 1991). This effect is attributed to a dose dependent inhibition by tocotrienols of 3 hydroxy-3 methyl glutaryl coenzyme A (HMGCoA) reductase thus inhibiting the in vivo synthesis of cholesterol in liver and thereby lowering serum cholesterol, particularly of the low density lipoprotein (Choi *et al*., 1989; Heave *et al*., 1990 and Ng *et al*., 1991).

Rao (1994) indicated that consumption of palm oil as the sole source of visible fat at a level of 30 per cent total fat calories did not adversely influence either the content of blood lipids or the aggregability of whole blood or platelets.

According to Grundy (1988) saturated fats are an important risk factor in hypercholesterolemia and cardio-vascular diseases only when they are consumed at high levels.

Both RPO and RBDPO exhibited a hypocholesterol effect despite their low PUFA; SFA (P;S) ratios (0.24). This effect was demonstrated to be due to the presence of minor components in palm oil (Rukmini, 1992).

Palm oil is the second most common vegetable oil produced in the world today and 90 per cent of it is used for nutritional purposes (Berger and Ong, 1985).

Khor and Tan (1987) reported that both the palm triglycerides and the palm oil vitamin E are important determinants for the non cholesterolemic effect of palm oil.

Palm oil consumption resulted in a significant increase in serum apo lipoprotein and a decrease in apo B demonstrating a favourable influence of dietary palm oil on this aspect of the cardiovascular risk profile (Hornstra and Sundram, 1987; and Wood *et al*., 1987).

Heber and Slater (1987) indicated that SFA present in processed foods increase serum cholesterol levels in humans.

Sanders (1996) commended that palm oil was not pro-aggregatory.

Palm oil contains a unique beneficial combination of MUFA, PUFA and SFA with around 40 per cent oleic, 10 per cent linoleic, 44 per cent palmitic and 5 per cent stearic acids. This unique combination was reported to produce beneficial effects on the serum lipid profiles like low total cholesterol (TC), triglycerides (TG) and low density lipoprotein cholesterol (HDL-C) (Manorama, 1998).

According to Siong (1992) carotenoids are precursors of vitamin A in the human biological system, β - carotene being the most active. In addition to vitamin A activity, carotenoids along with tocopherols are also powerful antioxidants which have been implicated in keeping both cancer and cardiovascular disease at bay. It has been reported by Sundram and Basiron (1998) that α carotene inhibited liver carcinogenesis in experimental mice.

Rukmini (1994) based on her study reported that rats fed RPO or RBDPO had significantly lower plasma cholesterol concentrations, than those fed with GNO. Significant inhibition of micronormal 3-hydroxy-3-methyl glutaryl coenzyme A reductase activity was observed in RPO and RBDPO groups, indicating reduced synthesis of endogenous cholesterol. Both RPO and RBDPO exhibited a hypocholesterolemic effect despite their low PUFA : SFA ratios (0.24). This effect was demonstrated to be due to the presence of minor components in palm oil.

Qureshi *et al*. (1986) and Chong (1989) reported that tocotrienols inhibit HMG CoA reductase activity significantly thereby resulting in hypercholesterolemia.

Rukmini and Manorama (1993) suggested that besides having favourable protective properties against cardiovascular diseases, RPO has a protective effect against mammary cancer in experimental rats. This may be possibly be due to anti-oxidant nutrients naturally present in palm oil, which act as scavengers of damaging oxygen free radicals thereby affording protection against cellular, aging, atherosclerosis and cancer.

Grande *et al*. (1970) observed that palm oil induced higher serum cholesterol and phospholipid levels than other oils.

According to Barron *et al*. (1974) and Coquet *et al*. (1977) there was no significant difference between palm oil and pea nut oil fed rats with regard to growth and reproduction.

According to Hornstra (1988) and WHO (1991) the influence of high fat intake on cardiovascular status depends on the fatty acid profile and the P:S ratio (polyunsaturated to saturated ratio).

Emken (1988); Gapor (1989), Sundram *et al*. (1989) and Ngah *et al*. (1991) reported that tocols together with carotenoids act as antioxidants to protect tissues and membranes from free radical damage and to prevent lung and oral cancers and the damaging effects of environmental toxins.

Toctotrienol has been reported to have a higher antioxidant activity than tocopherol (Serbinova *et al*., 1991).

Materials and Methods

MATERIALS AND METHODS

The study entitled "Shelf Life Studies on Red Palm Oil" is a comprehensive study carried out with an objective to assess the qualitative changes of red palm oil during storage.

The methodology followed in the study is presented under the following headings.

3.1 Collection of oil
3.2 Selection of containers
3.3 Storage in containers
3.4 Physico-chemical characters
3.5 Preparation of product
3.6 Cooking qualities
3.7 Organoleptic qualities of the product
3.8 Statistical analysis

3.1 Collection of oil

The red palm oil was collected from the processing unit at Central Plantation Crops Research Institute (Research Centre), Palode, Thiruvananthapuram.

3.2 Selection of containers

The containers selected for the study were plain glass bottles, coloured glass bottles, polyteraphthalate bottles, polythene pouches and tins (Plate 7).

PLATE 7 Red palm oil stored in different containers

3.3 Storage in containers

The oil was homogenised by heating to 40°C. Oil was poured into the containers without leaving much air space and sealed air tight.

3.4 Physico-chemical characters

The various physico-chemical characters studied were moisture, smoke point, specific gravity, acid value, peroxide value, B - carotene, vitamin E, iodine value and fatty acid composition.

3.4.1 Moisture

Moisture content was determined by A.O.A.C. method (1987).

3.4.2 Smoke point

This was determined by A.O.A.C. method (1987).

3.4.3 Specific gravity

Specific gravity was measured by the method outlined by the A.O.A.C. (1987).

3.4.4 Acid value

The acid value determination was used as a general indicator of the condition and edibility of the oils. It was determined by the method outlined by A.O.A.C. (1987).

3.4.5 Peroxide value

Peroxide value was measured by A.O.A.C. method (1987). This gives a measure of the primary oxidation by determining mainly the hydroperoxide content with an iodometric titration.

3.4.6 Iodine value

Iodine value is often the most useful and easily determined fat content for identifying an oil. Wij's method (A.O.A.C., 1987) was followed for the estimation.

3.4.7 β - carotene

For the measurement of carotene, 1% solution of the oil was accurately prepared in isooctane solvent and absorbance was measured at 445-450 nm as suggested by Palmoil Research Institute Malaysia (1988).

3.4.8 Vitamin E

Tocopherols were estimated by HPLC method standardised by Jayalekshmy *et al*. (1997) using NH_2 column and n-hexane isopropanal solvent system (96.4) A UV detector at 297 nm was used for detection of separated peaks and quantification was done after colibrating with individual forms of alpha, beta, gamma and delta tocopherols.

3.4.9 Fatty acid composition

Fatty acid methyl esters were prepared by using methanol sulphuric acid reagent and the fatty acid composition was determined by gas liquid chromatography. The column used was AP-FFAP (crosslinked FFAP) with a flame ionisation detector. Injection and detector temperatures were 250°C and 300°C respectively. The column temperature was 180°C Nitrogen (20 ml/mn) was used as carrier gas (Jayalekshmy, 1994).

3.5 Preparation of product

The cooking method selected for the preparation of product was baking.

The cakes were prepared every month using red palmoil stored in five different containers and were subjected to organoleptic evaluation. A cake made with butter was kept as control. Flour and red palmoil used for the preparation of cake was in the ratio 1:0.2.

3.6 Cooking qualities

Cooking qualities like cooking time, increase in volume, crustyness, fluffyness, spongyness, springyness and evenness in baking were assessed.

Cooking time was recorded for each cake. The percentage increase in volume of the cakes were calculated from the weight of raw ingredients and the cake after cooking.

Crustyness, fluffyness, spongyness, springyness and evenness in baking were scored by the panel members with the aid of a score card (Appendix I).

3.7 Organoleptic quality

Organoleptic qualities play an important role in evaluating the quality of a food product. For adjudging consumer acceptability, organoleptic evaluation of any food product is essential.

The panel members for sensory analysis at the laboratory level were selected from a group of students. These judges were selected through triangle test as suggested by Mahony (1985). Details are given in Appendix-II.

The sensory analysis of panel members were done using the scoring method and scoring was done as suggested by Swaminathan (1974). The major quality attributes included in the score card were appearance, colour, texture, taste, flavour and doneness (Appendix-III).

3.8 Statistical analysis

Statistical analysis was carried out as follows.

Analysis of variance was applied for the comparison of containers with respect to the changes occurring during storage (Snedcor and Cochran, 1967).

Results

RESULTS

The study entitled "Shelf life studies on red palm oil" was conducted to ascertain the changes in the quality of the oil during storage.

4.1 Physico-chemical changes

The various characters studied were specific gravity, smoke point, moisture, acid value, peroxide value, β-carotene, vitamin E and iodine value and fatty acid composition.

The initial values for all these parameters before storage are given in Table 5.

Table 5 Initial values of various parameters of RPO prior to storage

Specific gravity	0.90
Smoke point	185°C
Moisture	0.119%
Acid value	4.76 mg/g
Free fatty acid	2.12%
Peroxide value	7.82 meq/kg
β-carotene	555 ppm
Vitamin E	900 mg/kg
Iodine value	52.34 (Wij's)

The close scrutiny of the data revealed that the specific gravity was almost steady through out the storage of six months irrespective of the containers (Table 6).

Table 6 Changes in specific gravity during storage

Containers	Storage period (months) 1	2	3	4	5	6	Mean
Tin	0.904	0.903	0.904	0.906	0.905	0.904	0.904
Polythene pouch	0.903	0.905	0.906	0.904	0.909	0.900	0.905
Polyteraphthalate bottle	0.900	0.906	0.904	0.907	0.909	0.903	0.904
Plain glass bottle	0.903	0.905	0.905	0.907	0.901	0.903	0.904
Coloured glass bottle	0.900	0.902	0.904	0.904	0.906	0.903	0.902
Mean	0.902	0.904	0.904	0.905	0.906	0.903	

F - 66**
SE - 0.0003
CD - 0.001
** Significant at 1% level

Table 7 Changes in smoke point during storage (°C)

Containers	Storage period (month) 1	2	3	4	5	6	Mean
Tin	180	175	167	165	160	160	167.8
Polythene pouch	175	170	165	165	163	162	166.6
Polyteraphthalate bottle	172	170	168	165	165	162	167.0
Plain glass bottle	170	170	168	165	165	160	167.1
Coloured glass bottle	180	175	170	165	162	160	167.8
Mean	175.4	170.6	165.6	165	164.6	162.4	

F - 39.125**
SE - 0.547
CD - 1.549
** Significant at 1% level

Table 7 revealed the change in smoke point of the oil during storage. The initial smoke point was 185°C. There was a general decreasing trend in smoke point for all the oil samples. From the data it can be seen that on the fourth month all the oil samples had uniform smoke point of 165°C. The final smoke point of the samples ranged between 160 and 162°C. In both tin and coloured glass bottle the smoke point fell from 175°C to 162°C. In polyteraphthalate bottle it was from 172°C to 162°C and in plain glass bottles it was from 170°C to 160°C. The statistical analysis did not show any significant difference in the rate of decrease occurring in all the containers, whereas the decrease in smoke point in all the samples during storage was significant.

Table 8 Changes in moisture content during storage (per cent)

Containers	Storage period (month)						Mean
	1	2	3	4	5	6	
Tin	0.12	0.12	0.15	0.15	0.18	0.20	0.15
Polythene pouch	0.12	0.12	0.15	0.16	0.20	0.20	0.16
Polyteraphtharate bottle	0.12	0.13	0.15	0.16	0.18	0.21	0.16
Plain glass bottle	0.12	0.13	0.15	0.16	0.19	0.20	0.16
Coloured glass bottle	0.13	0.13	0.14	0.16	0.20	0.21	0.16
Mean	0.12	0.13	0.15	0.16	0.196	0.20	

F - 59.340**
SE - 0.0005
CD - 0.001
** Significant at 1% level

The moisture content of oil stored in different containers throughout the storage period was as given in Table 8. The data indicated that there was significant increase in moisture content as the storage period progressed. It was found that the change in moisture content in different containers were similar. The increase in moisture content was maximum at the fifth and sixth month of storage.

Table 9 Changes in acid value during storage (mg/g)

Containers	Storage period (month)						Mean
	1	2	3	4	5	6	
Tin	5.50	5.97	6.04	7.75	8.21	9.83	7.21
Polythene pouch	5.07	5.54	5.91	7.44	8.39	9.79	7.02
Polyteraphthalate bottle	5.59	5.62	5.76	7.09	8.14	9.94	7.02
Plain glass bottle	5.36	5.48	5.95	7.64	8.37	10.66	7.38
Coloured glass bottle	5.24	5.61	6.13	7.85	8.83	9.73	7.17
Mean	5.35	5.64	5.96	7.55	8.39	10.09	

F - 11.075**
SE - 0.067
CD - 0.191
** Significant at 1% level

The acid value of oil in different containers for six months are as given in Table 9. The data revealed that in all cases there was a significant increase in acid value on the fourth month. There was significant increase of acid value in oil samples stored in polythene pouch (9.79), polyteraphthalate bottle (9.94) and in plain glass bottle (10.60) during the fifth and sixth month whereas in tin and coloured bottle the increase in acid value of oil was significant in the sixth month only.

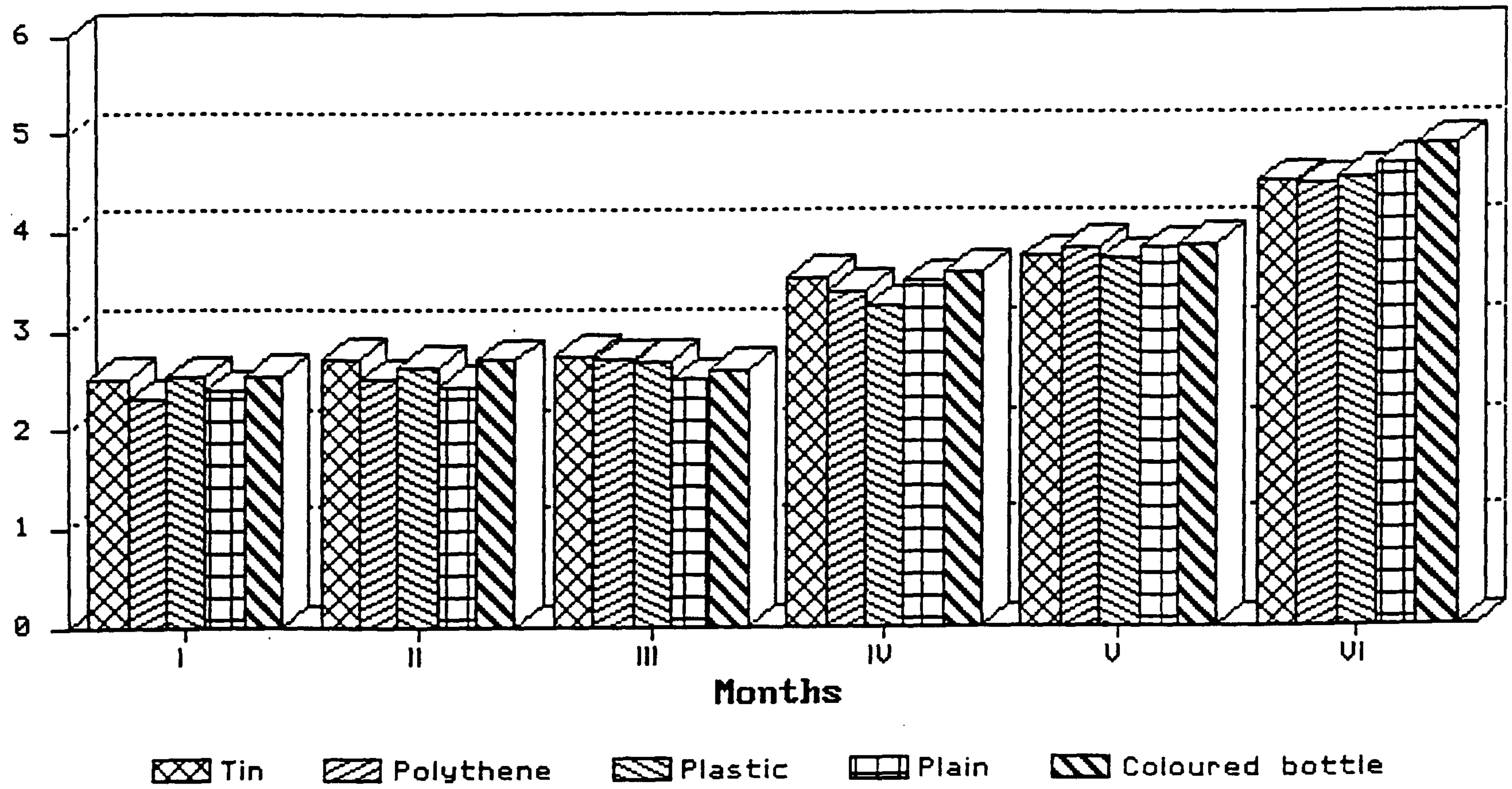
Table 10 Changes in free fatty acid content during storage (per cent)

Containers	Storage period (month)						Mean
	1	2	3	4	5	6	
Tin	2.51	2.72	2.75	3.53	3.74	4.49	3.29
Polythene pouch	2.31	2.53	2.73	3.39	3.83	4.46	3.20
Polyteraphthalate bottle	2.52	2.63	2.68	3.23	3.71	4.53	3.21
Plain glass bottle	2.39	2.44	2.50	3.48	3.82	4.86	3.36
Coloured glass bottle	2.55	2.70	2.60	3.58	3.87	4.66	3.21
Mean	2.46	2.60	2.65	3.44	3.796	4.60	

F - 1.641**
SE - 0.085
CD - 0.241
** Significant at 1% level

The data obtained for the free fatty acid content of the oil samples is depicted in Table 10 and Fig. 1. There was an increase in free fatty acid content in the oils stored in all the containers throughout the storage period. The increase was significant from the fourth month onwards. The rate of change occurring in each container was significantly different for all the months. The initial free fatty acid content was 2.1%. The maximum increase in free fatty acid was found in

Fig. 1 FREE FATTY ACID CONTENT



plain glass bottle (103%). Oil samples in polythene pouches had an increase of 93% whereas in coloured glass bottle had 82.7%. The increase in tin (78.9%) and polyteraphthalate bottles (79.7%) were comparable.

The fatty acid composition of the oil were analysed and the results are given in Table 11 and 12. Palmoil contains 50 per cent of saturated fatty acids and 50 per cent of unsaturated fatty acids. The fatty acids mainly found in palmoil are myristic acid (0.6 - 1.7 per cent), palmitic acid (41.1-47.0 per cent), stearic acid (3.7-5.6 per cent), oleic acid (28.2-43.5 per cent) and linolenic acid (0-0.5 per cent).

The analysis of oil before storage showed a fatty acid composition in percentage as follows ie, $C_{14:0}$ (1.53), $C_{16:0}$ (50.47), $C_{18:0}$ (3.53), $C_{18:1}$ (35.03) and $C_{18:2}$ (9.42) (Fig. 2).

Table 11 Fatty acid composition after 3 months

Fatty acid composition	Containers				
	Tin	Polythene pouch	Polyteraphthalate bottle	Plain glass bottle	Coloured glass bottle
$C_{14:0}$	1.95	1.63	1.92	1.63	1.76
$C_{16:0}$	50.63	49.35	50.32	49.06	50.77
$C_{18:0}$	3.24	3.49	3.14	3.58	3.50
$C_{18:1}$	38.54	36.37	34.55	36.23	34.73
$C_{18:2}$	9.31	8.99	9.18	9.39	9.12

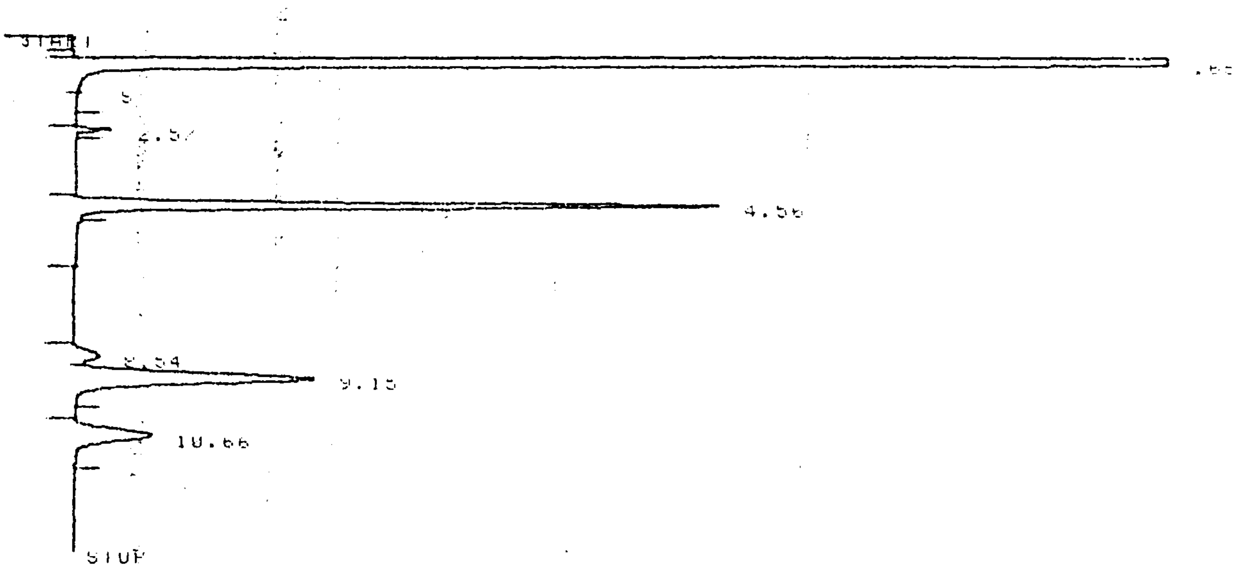


Fig.2 Fatty acid profile of red palm oil prior to storage

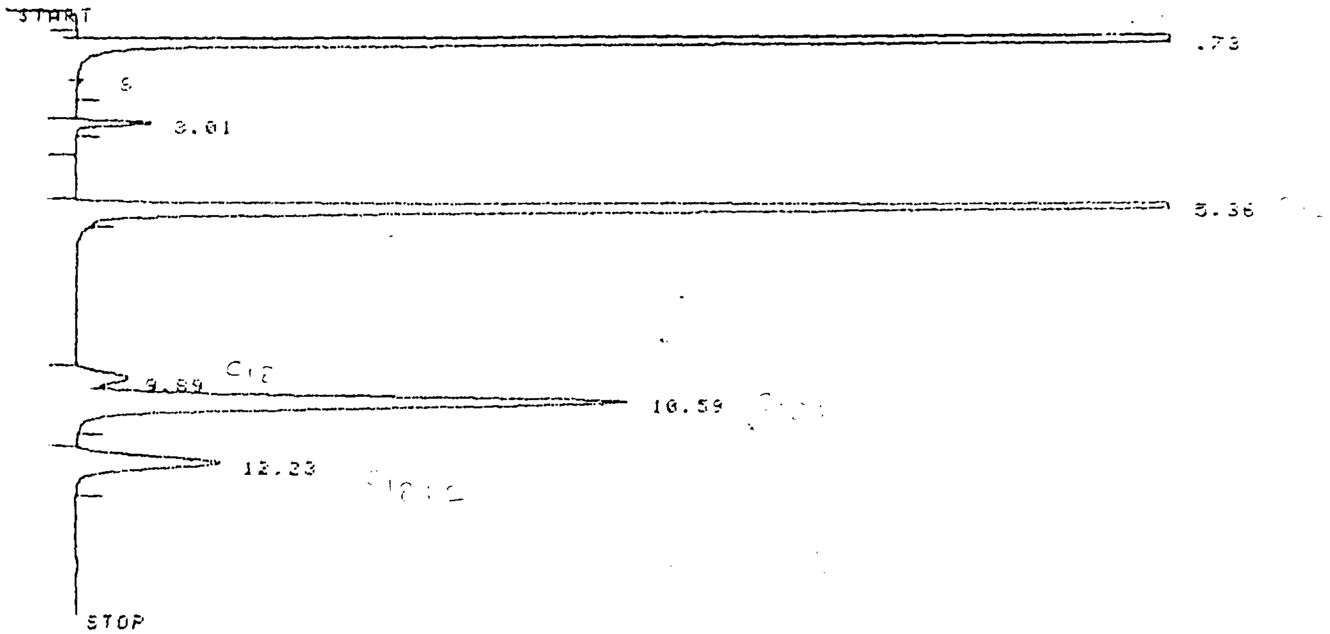


Fig.3. Fatty acid profile of red palm oil stored in tins for three months

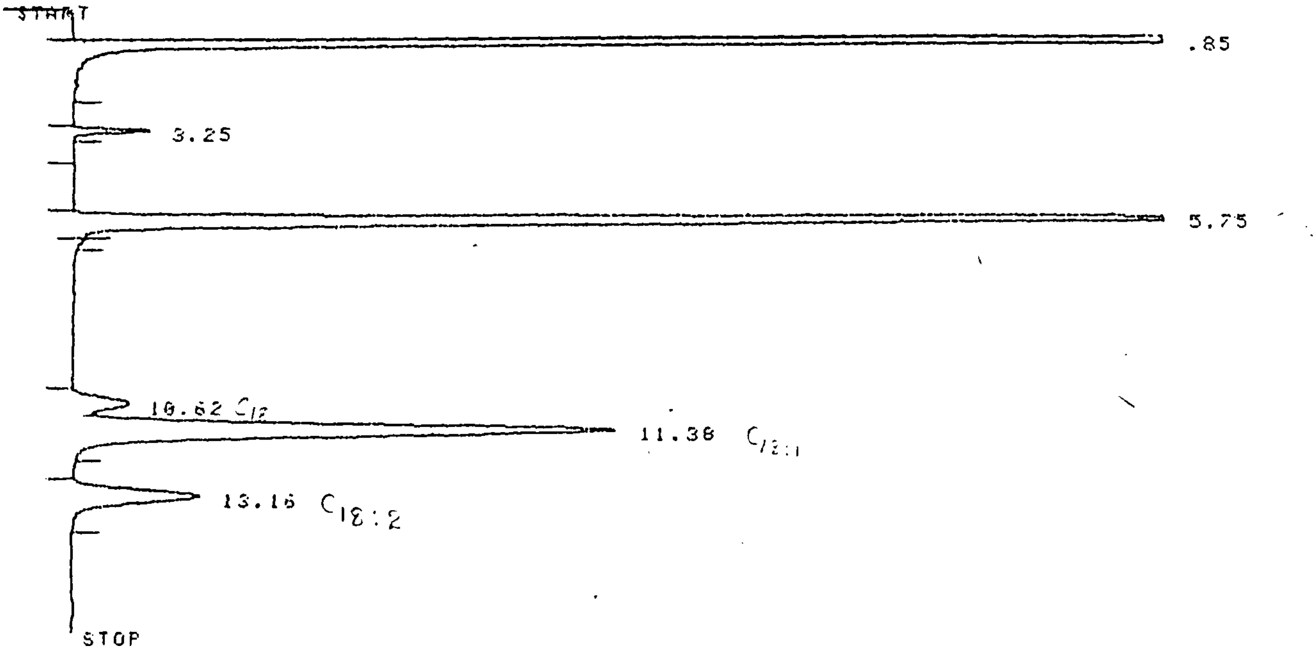


Fig.4. Fatty acid profile of red palm oil stored in polythene pouches for three months

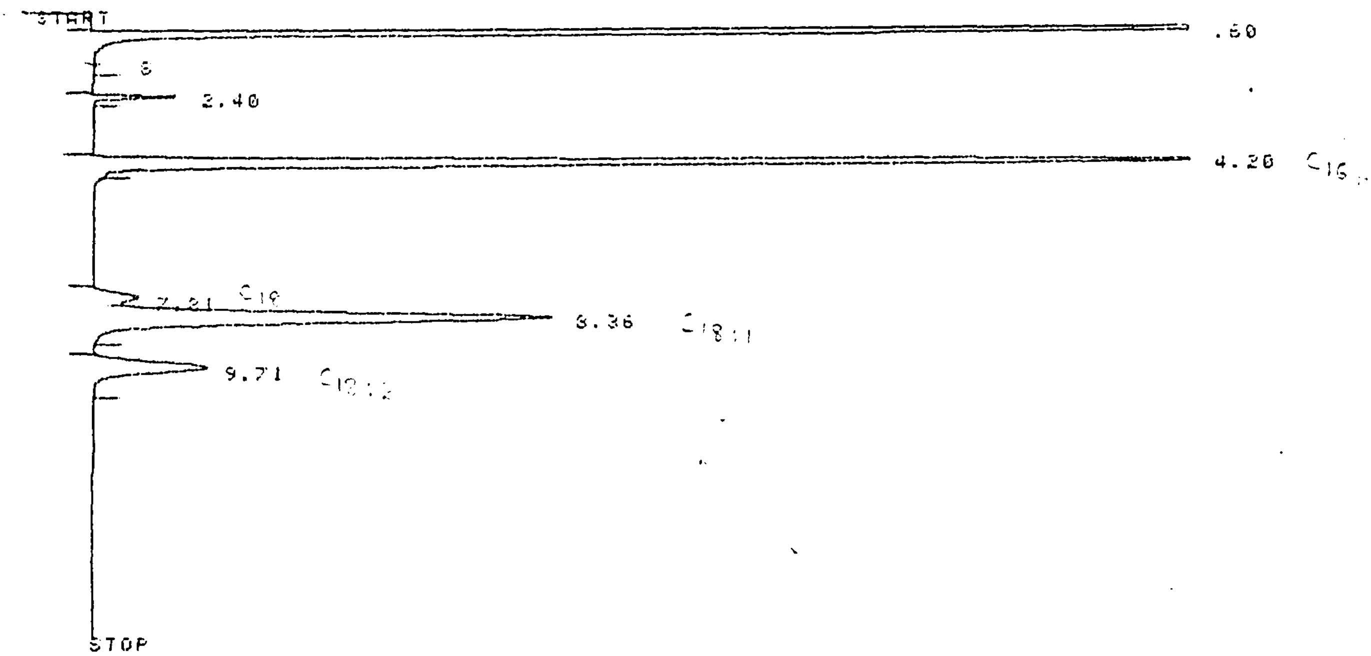


Fig.5. **Fatty acid profile of red palm oil stored in polyteraphthalate bottles for three months**

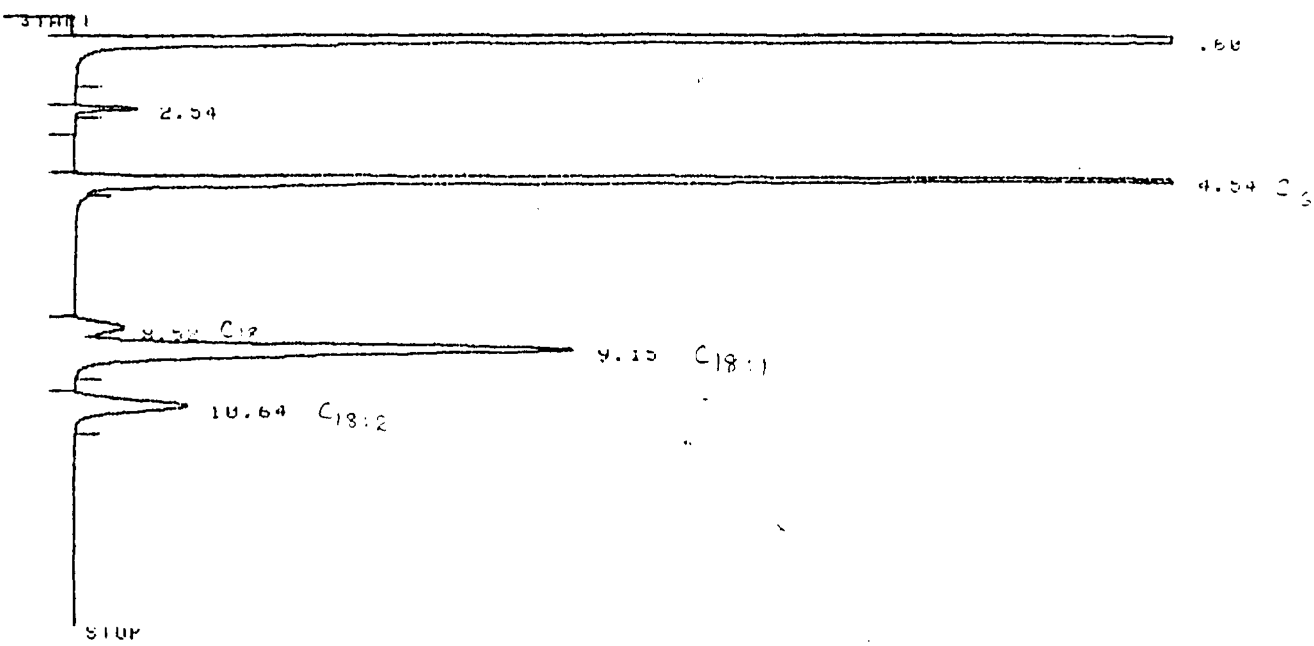


Fig.6. Fatty acid profile of red palm oil stored in plain glass bottles for three months

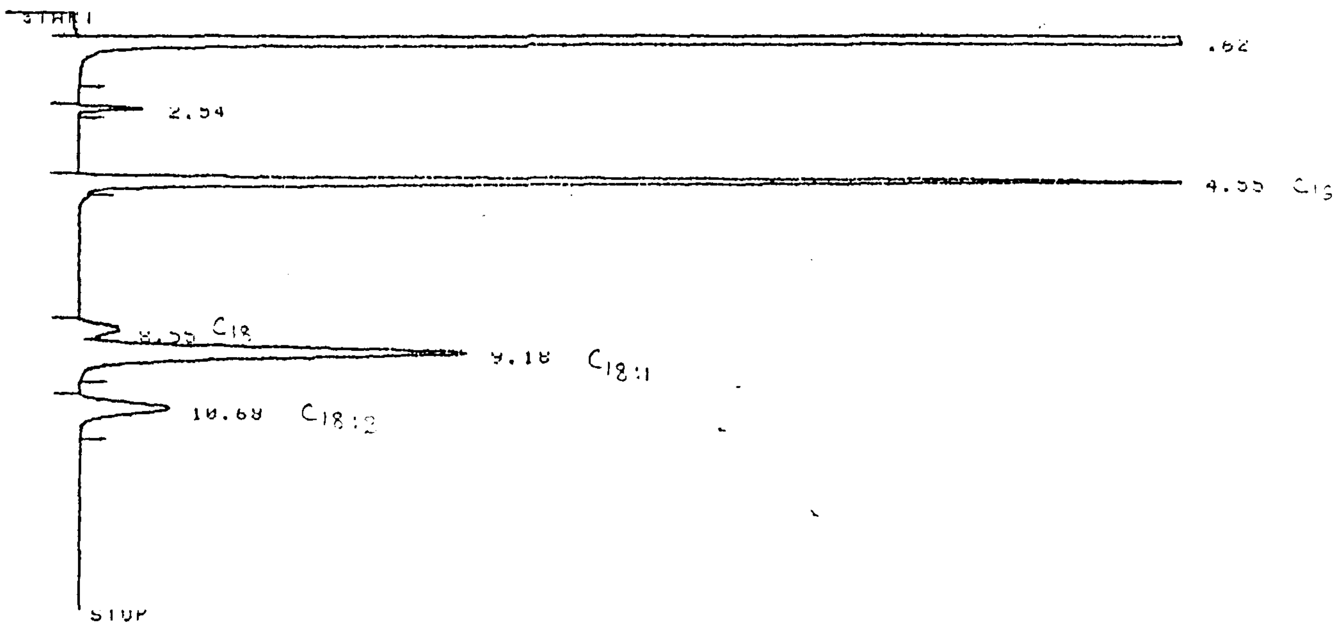


Fig.7. Fatty acid profile of red palm oil stored in coloured glass bottles for three months

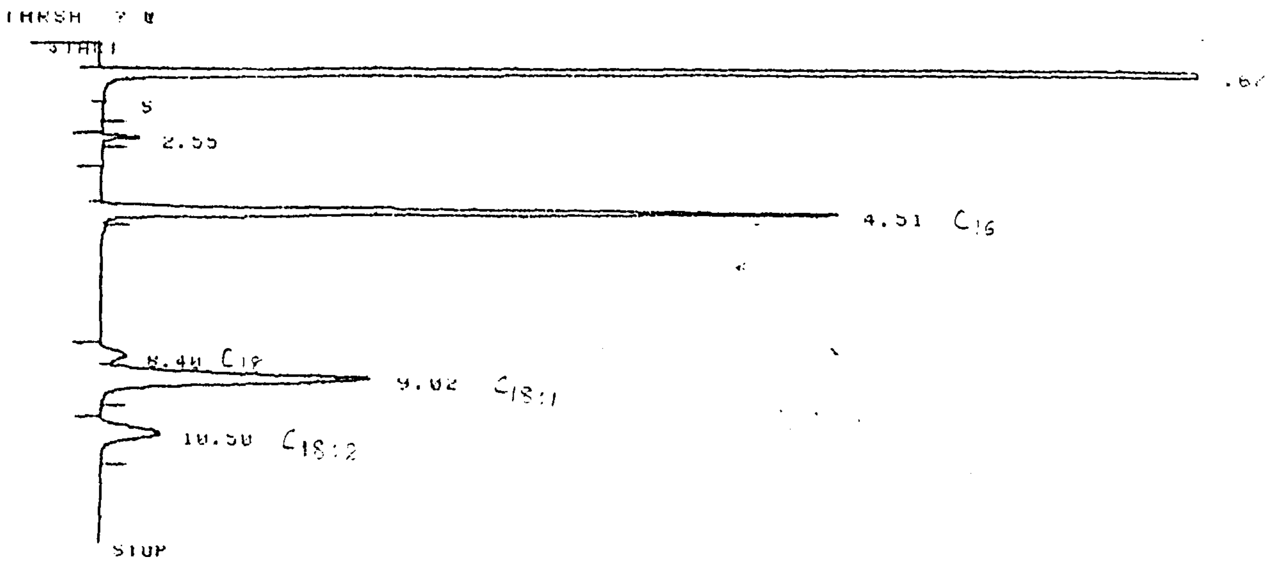


Fig.8. Fatty acid profile of red palm oil stored in tins for six months

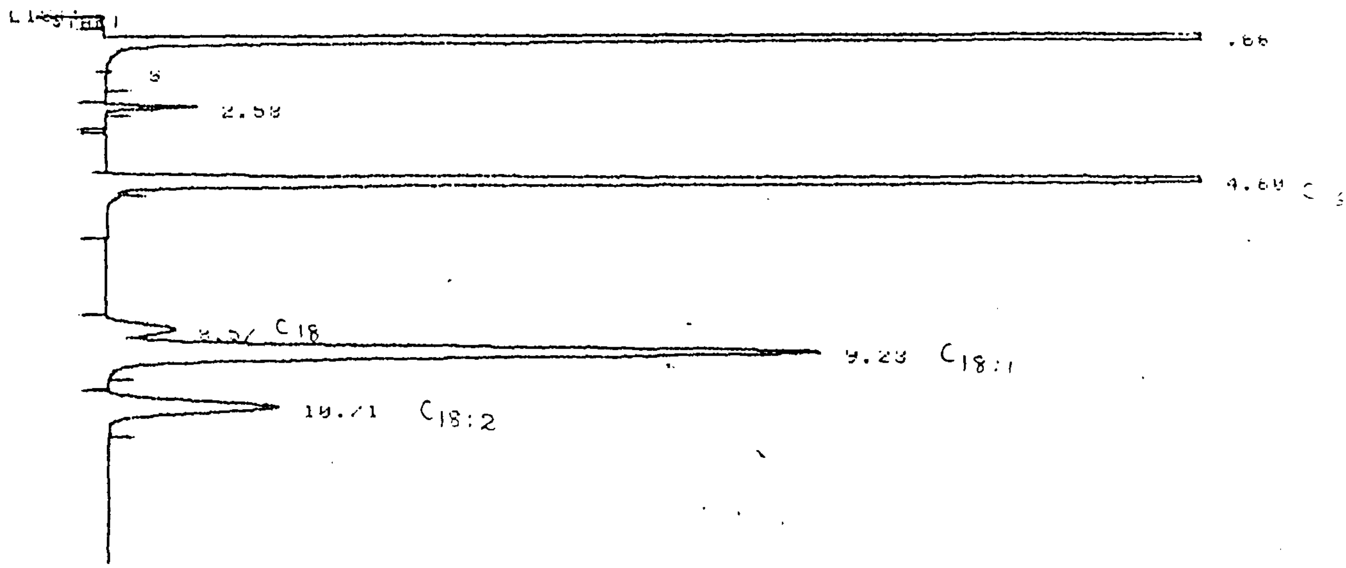


Fig.9. Fatty acid profile of red palm oil stored in polythene pouches for six months

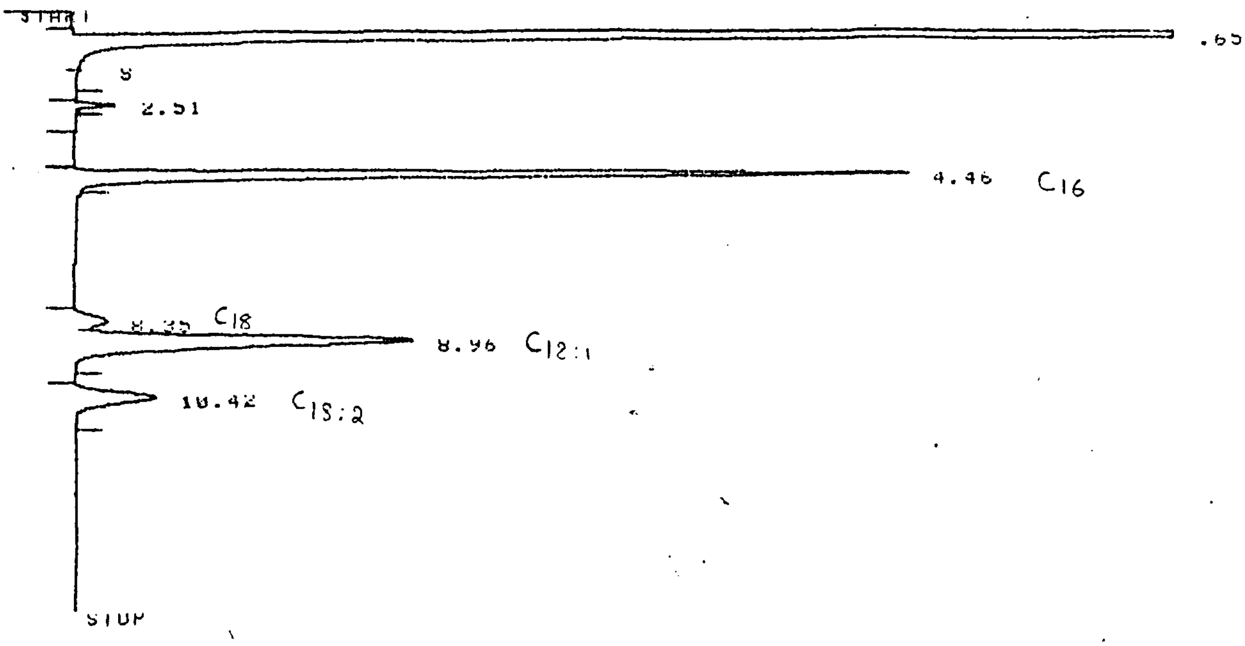


Fig.10. Fatty acid profile of red palm oil stored in polyteraphthalate bottles for six months

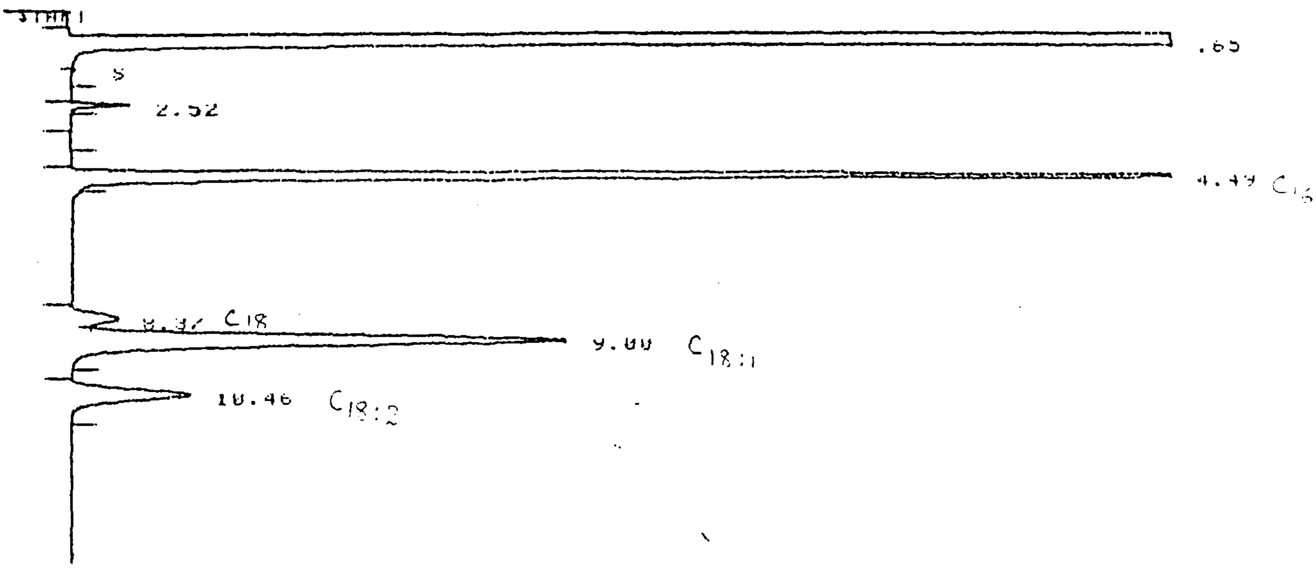


Fig.11. Fatty acid profile of red palm oil stored in plain glass bottles for six months

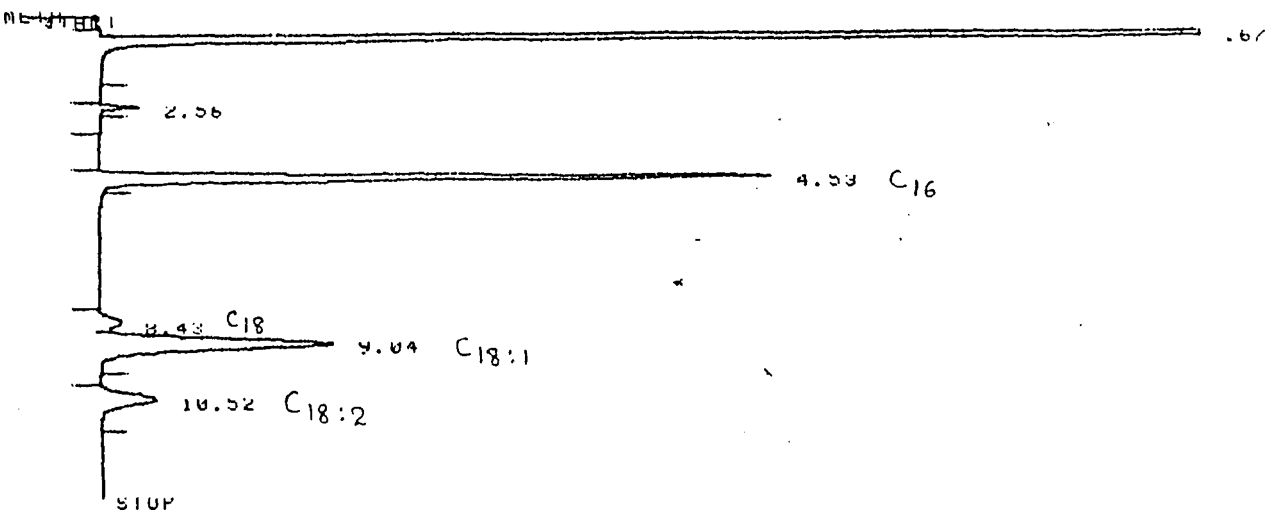


Fig.12. Fatty acid profile of red palm oil stored in coloured glass bottles for six months

The fatty acid composition during 3rd month (Table 11) showed a slight increase in $C_{16:0}$ a saturated fatty acid and a decrease in $C_{18:1}$, an unsaturated fatty acid (Fig. 3 to 7).

During the 6th month (Table 12) there was a decrease in the saturated fatty acid content (Fig. 8 to 12)

Table 12 Fatty acid composition after 6 months

	Containers				
Fatty acid composition	Tin	Polythene pouch	Polyteraphthalate bottle	Plain glass bottle	Coloured glass bottle
$C_{14:0}$	1.51	1.53	1.48	1.45	1.80
$C_{16:0}$	49.00	48.38	47.86	47.83	50.86
$C_{18:0}$	3.45	3.41	3.51	3.56	3.30
$C_{18:1}$	36.80	35.25	37.03	37.26	35.09
$C_{18:2}$	9.02	9.41	9.44	9.83	9.25

Table 13 Changes in peroxide value during storage (meq/kg)

Containers	Storage period (month)						Mean
	1	2	3	4	5	6	
Tin	8.37	8.64	9.38	11.58	19.10	27.57	14.10
Polythene pouch	12.77	15.40	25.26	29.80	32.17	39.39	25.79
Polyteraphthalate bottle	9.60	9.63	15.88	18.59	19.80	31.62	17.52
Plain glass bottle	6.47	6.50	6.94	18.67	9.06	17.06	9.30
Coloured glass bottle	6.12	6.90	8.54	10.17	10.37	13.72	9.19
Mean	8.77	9.41	13.20	15.76	18.10	24.67	

F - 30.723**
SE - 0.719
CD - 2.034
** Significant at 1% level

The changes in peroxide value are indicated in Table 13 and Fig. 13. The peroxide value of the stored oil in different containers showed significant differences. The rate of increase was different for each container in each month. The highest value was for polythene pouch (39.39) whose initial value was (12.77). There was a three fold increase in peroxide value. The least increase was noticed in the samples stored in coloured glass bottle (13.72). The peroxide value of the samples in rest of the containers were intermediate to that of polythene pouches and coloured glass bottles. The peroxide values of oil stored in polyteraphthalate bottle, tin and plain glass bottles were 31.62, 27.57 and 17.06 respectively. In the case of polythene pouch there was significant change in peroxide value as the storage period increased whereas in coloured and plain glass bottle the increase was significant only in the sixth month. Significant change was observed in the fifth month in palmoil stored in tin container. From the third month itself there was significant increase in peroxide value of the oil stored in polyteraphthalate container.

Fig.13 PEROXIDE VALUE

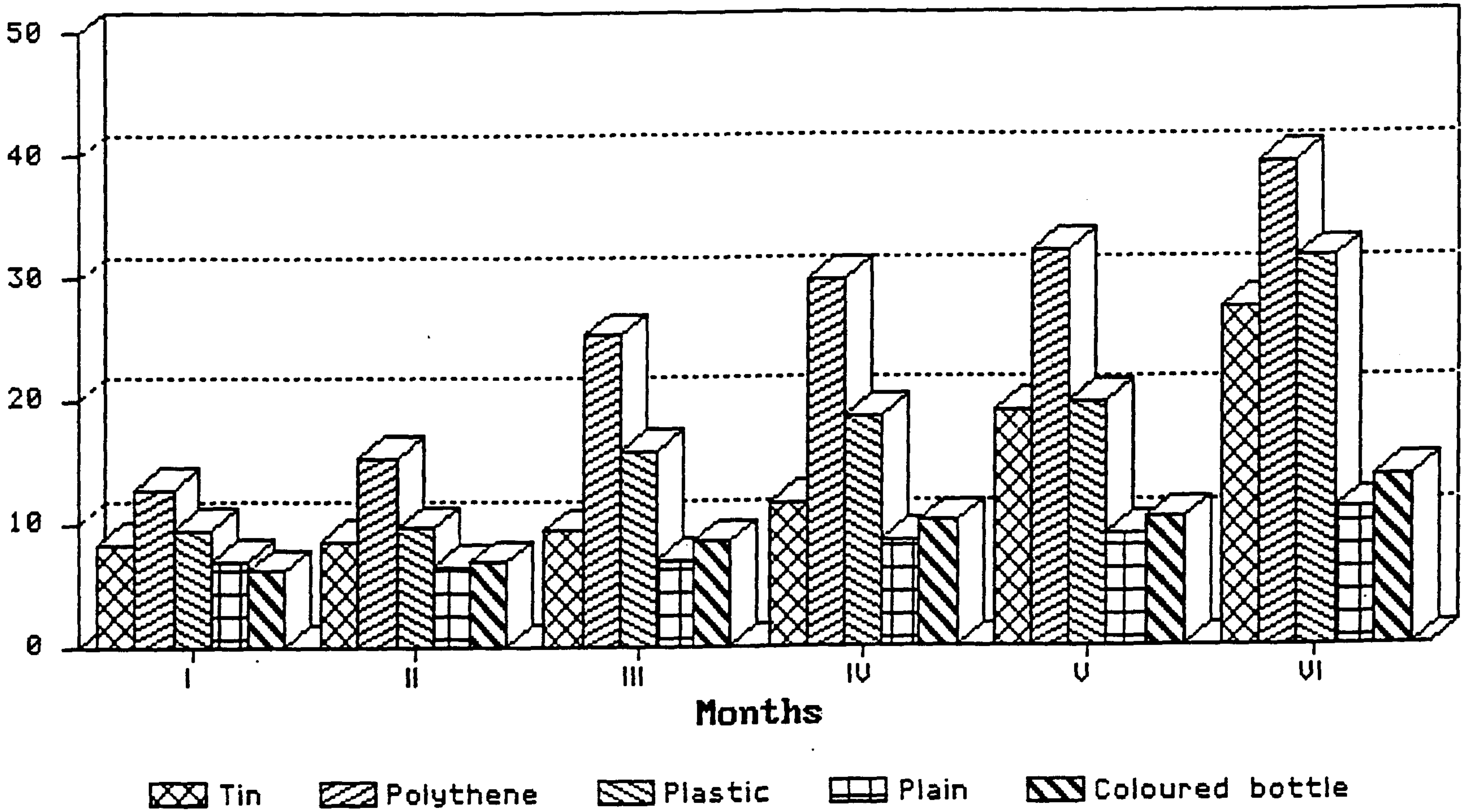


Table 14 Changes in β-carotene content during storage (ppm)

Containers	Storage period (month)						Mean
	1	2	3	4	5	6	
Tin	476.07	461.13	449.54	419.38	387.22	386.06	429.90
Polythene pouch	436.32	434.32	410.96	322.86	315.59	311.37	371.90
Polyteraphthalate bottle	471.60	467.26	460.37	430.49	414.02	386.83	438.42
Plain glass bottle	497.53	464.19	450.79	439.30	402.53	391.80	437.19
Coloured glass bottle	474.49	465.98	448.37	440.06	396.40	392.96	445.21
Mean	470.33	463.20	443.95	412.72	383.15	373.80	

F - 61.655**
SE - 2.195
CD - 6.211
** Significant at 1% level

Thorough examination of the values obtained for β - carotene indicated a consistant decrease in the β-carotene content throughout the storage period (Table 14 and Fig.14). The initial β-carotene content was 555 ppm. The maximum loss was noticed in polythene pouches in which the carotene content came down to 311.37 which accounts to the loss of 43.8 per cent. The minimum loss was found in coloured glass bottle that was a loss of only 29.1 per cent. The percentage loss from tin was 30.4 per cent, from polyteraphthalate bottle it was 30.3 per cent and that from plain glass bottle it was 29.4 per cent. The loss of B-carotene from coloured glass bottles and plain glass bottles were comparable. Similarly the loss from tin and polyteraphthalate bottles were also comparable.

Fig. 14 β- CAROTENE

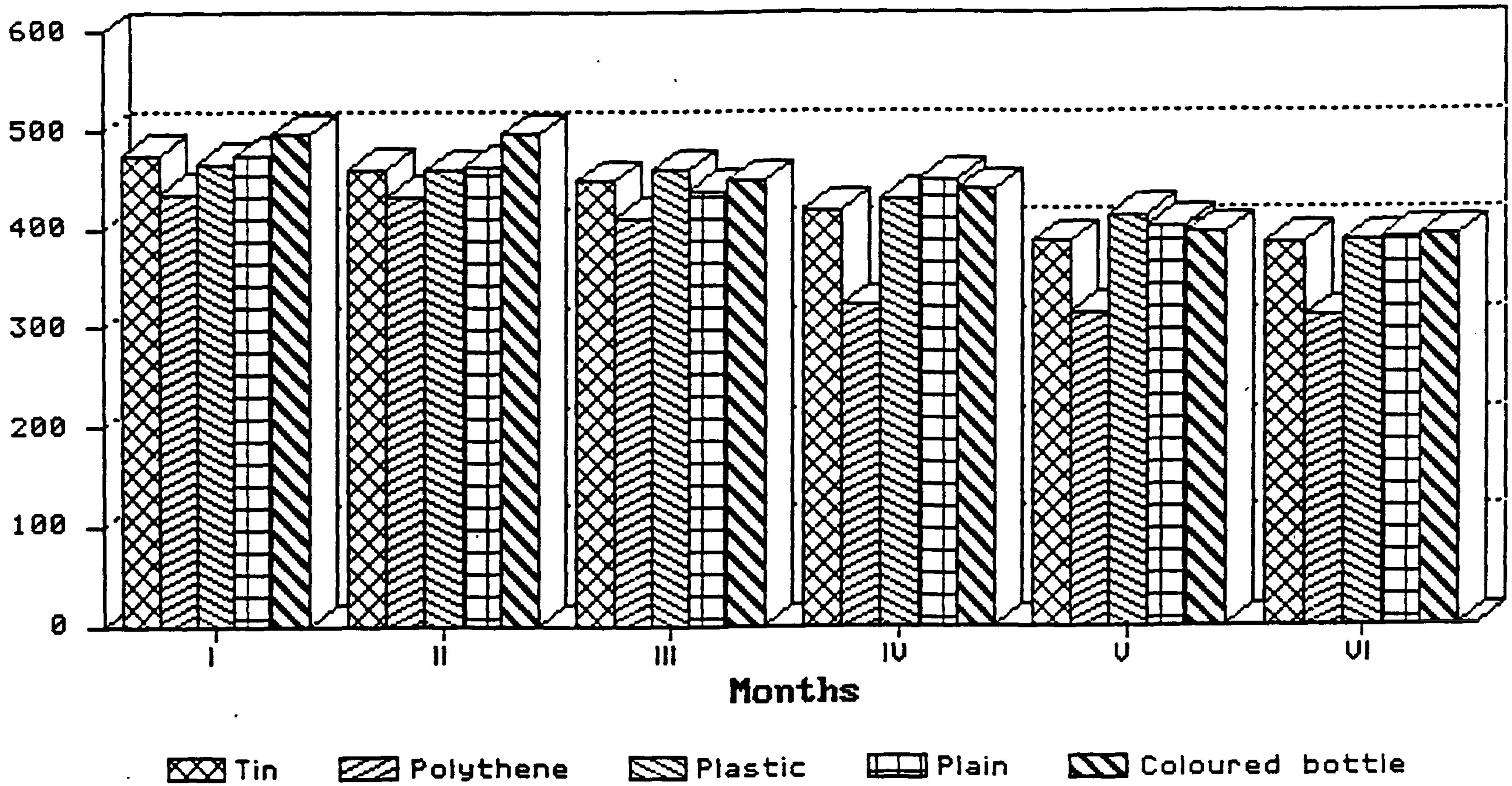


Table 15 Changes in Vitamin E content during storage (mg/kg)

Containers	Storage period (month)					
	1	2	3	4	5	6
Tin	883.4	821.2	807.3	785.6	743.0	725.0
Polythene pouch	860.0	754.8	635.0	526.5	424.9	334.2
Polyteraphthalate bottle	867.3	794.6	726.4	694.4	595.0	524.0
Plain glass bottle	894.4	871.3	832.4	795.0	773.7	769.0
Coloured glass bottle	876.7	782.2	763.5	742.3	726.8	704.0

The initial vitamin E content of the oil was 900 ppm. The data indicating the vitamin E content of the oil samples during the period of storage is given in Table 15 (Fig.15). The data showed a decreasing trend in the vitamin E content of the samples. The loss from polythene pouches were found to be tremendous. The carotene content in polythene pouches came down to 334.2 ppm. The percentage loss was 62.8 per cent. There was a loss of 41.8 per cent of vitamin E from polyteraphthalate bottles. The loss of vitamin E from the other containers were comparable. The loss from plain glass bottle, tin and coloured glass bottles were 14.5 per cent, 19.4 per cent and 21.7 per cent respectively.

Fig. 15 VITAMIN E

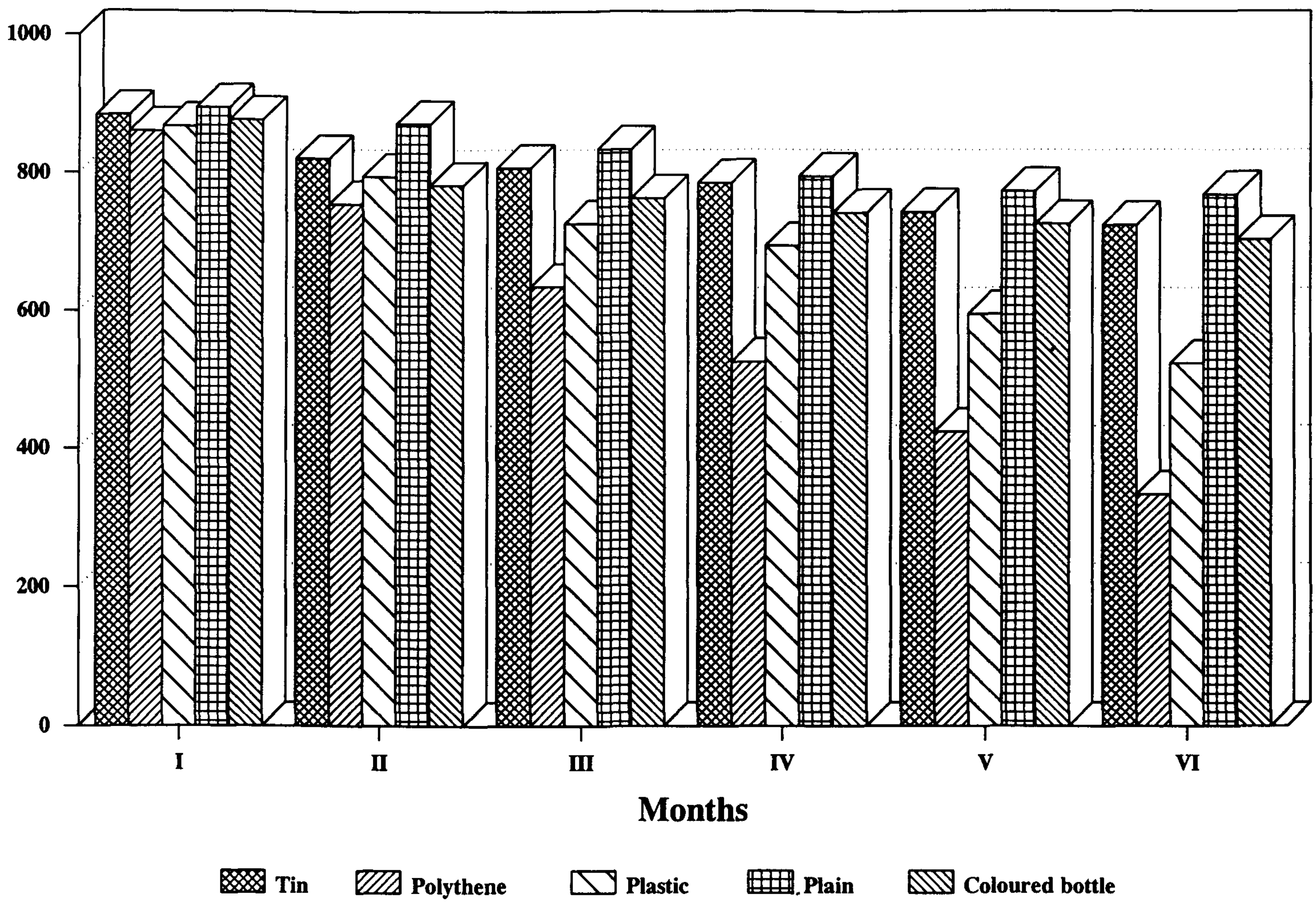


Table 16 Changes in iodine value during storage (Wij's)

Containers	Storage period (month)						Mean
	1	2	3	4	5	6	
Tin	53.50	52.95	53.40	52.32	52.66	52.57	52.90
Polythene pouch	53.49	53.49	53.40	52.60	52.08	52.35	52.90
Polyteraphthalate bottle	53.15	53.67	52.89	52.59	52.92	52.49	52.95
Plain glass bottle	53.83	53.26	53.52	52.14	52.07	52.79	52.93
Coloured glass bottle	53.67	53.28	53.71	52.23	52.90	52.34	53.02
Mean	53.53	53.33	53.38	52.38	52.52	52.50	

F - 25.022**
SE - 0.061
CD - 0.174
** Significant at 1% level

The iodine value obtained for the samples are given in Table 16. There was no significant difference in iodine value with respect to the containers. There was a slight decrease in iodine value as the storage period progressed. The iodine value ranged from 52.07 to 53.53.

The organoleptic evaluation of the stored oils were carried out. The results are given in Tables 17, 18 and 19.

Table 17 Changes in taste parameter due to storage

Containers	Storage period (month)						Mean
	1	2	3	4	5	6	
Tin	3.6	3.3	2.8	2.6	2.5	2.9	2.8
Polythene pouch	3.8	3.5	2.6	2.5	2.5	2.2	2.8
Polyteraphthalate bottle	3.8	3.6	2.6	2.1	3.0	2.1	2.9
Plain glass bottle	3.7	3.2	2.4	2.9	2.9	2.3	3.0
Coloured glass bottle	3.8	3.6	2.8	2.7	2.9	2.5	3.1
Mean	3.7	3.4	2.8	2.7	2.5	2.5	

F - 1.10**
SE - 0.247
CD - 0.685
** Significant at 1% level

The mean scores obtained for the attribute, 'taste' of the oil samples revealed that there was steady decrease in the scores obtained for taste of stored oil as the storage period advanced. Mean values obtained for the taste quality ranged between 2.8 and 3.1. Analysis of the scores revealed that there was a gradual decrease in the scores as the storage period progressed. The scores fell from 3.7 to 2.5 during the sixth month. The scores obtained for the oil stored in tin and polythene pouch were on par (2.8). The highest score (3.1) was recorded for the oil stored in the coloured bottle. There was no significant difference among the mean scores.

Table 18 Changes in odour parameter due to storage

Containers	Storage period (month)						Mean
	1	2	3	4	5	6	
Tin	3.8	3.7	2.5	2.0	2.7	2.4	2.9
Polythene pouch	3.7	3.1	2.9	2.5	2.5	2.3	3.4
Polyteraphthalate bottle	3.7	3.3	2.4	2.2	2.3	2.4	3.2
Plain glass bottle	3.6	3.7	2.6	2.6	2.4	2.1	3.4
Coloured glass bottle	3.8	3.6	2.4	2.2	2.9	2.4	3.4
Mean	3.7	3.5	2.5	2.3	2.5	2.3	

F - 0.72**
SE - 0.259
CD - 0.718
** Significant at 1% level

The result obtained for the evaluation of attribute 'odour' of the oil is given in Table 18. The mean scores indicated that the odour of the oil stored in tin was poor and the oil stored in the rest of the containers were just satisfactory. The mean scores ranged from 2.9 to 3.4. The scores obtained for the oil stored in polythene pouch, plain glass bottle and coloured glass bottles were on par (3.4) and for the oil stored in polyteraphthalate bottle was 3.2. Along that there was a decreasing trend in the mean scores during storage. The odour was satisfactory at the beginning of the storage but it was recorded to be poor at the end of the storage period. However the change was not statistically significant.

Table 19 Overall acceptability of stored oil samples

Containers	Storage period (month)						Mean
	1	2	3	4	5	6	
Tin	3.7	3.5	2.4	2.0	2.6	2.1	2.7
Polythene pouch	3.9	3.1	2.8	2.5	2.5	2.4	2.8
Polyteraphthalate bottle	3.8	3.6	2.3	2.2	2.0	2.1	2.6
Plain glass bottle	3.8	3.4	2.5	2.0	2.9	2.1	2.8
Coloured glass bottle	3.8	3.8	2.3	2.2	2.9	2.2	2.8
Mean	3.7	3.4	2.4	2.1	2.5	2.2	

F - 1.09**
SE - 0.224
CD - 0.620
** Significant at 1% level

The overall acceptability scores are given in Table 19. The mean scores showed that all the oil stored were of poor quality. There is no significant difference between the scores obtained for the oil in different containers. The scores were between 2.6 and 2.8. The mean scores for the oil stored in polythene pouch, plain glass bottle and coloured glass bottle were on par (2.8). The scores obtained for the oil stored in tin and polyteraphthalate bottles were 2.7 and 2.6 respectively. The quality of the oil was satisfactory during first two months whereas it was found that the quality of the oil was poor during the subsequent months. Statistical analysis showed that the difference was not significant.

4.2 Cooking qualities

In order to assess the organoleptic changes of the oil a product (cake) was made using the stored samples of palmoil every month (Plate 9). A control made with butter was kept for the comparison of the cakes (Plate 8).

The cooking qualities assessed were cooking time, increase in volume, crustyness, fluffyness, springyness, spongyness and evenness in baking.

Table 20 Time taken for baking cake

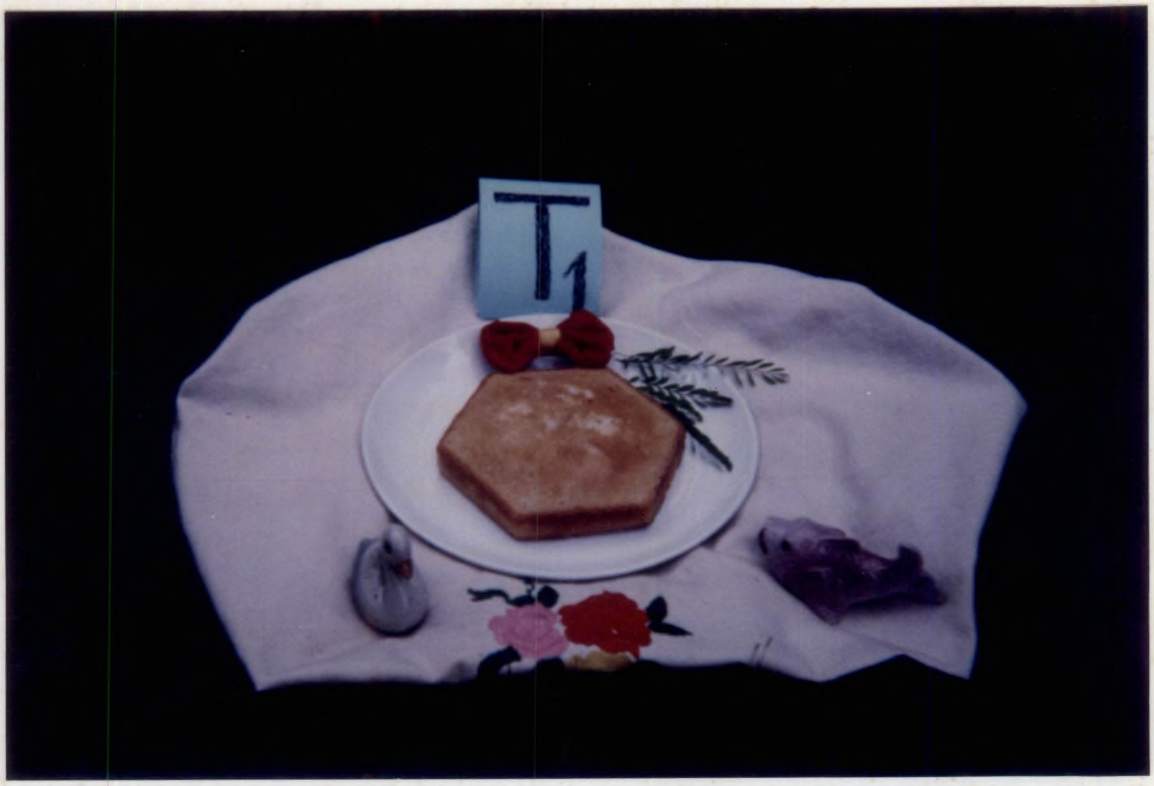
Containers	Storage period (month)						Mean
	1	2	3	4	5	6	
Tin	45.5	42.0	43.0	42.0	43.0	44.0	43.1
Polythene pouch	43.0	45.0	42.0	45.5	43.0	42.0	43.3
Polyteraphthalate bottle	45.0	42.0	43.0	44.0	43.0	42.0	43.1
Plain glass bottle	42.0	44.0	43.0	45.5	42.0	45.0	43.5
Coloured glass bottle	44.0	43.0	42.0	43.0	45.0	42.0	43.1
Control	42.0	43.0	42.5	44.0	42.0	43.0	43.2
Mean	43.8	43.2	42.6	43.8	43.8	43.0	

F - 141.347**
SE - 0.100
CD - 0.283

The values given in Table 20 indicated the variation in cooking time of cakes. The values obtained revealed that all the cakes irrespective of the type of fat used had

PLATE 8 Cake made with butter

PLATE 9 Cake made with red palm oil


T1


T4

comparable cooking time. The values ranged from 43.1 to 43.5. It was visible that there was no significant change in cooking time during 6 months of storage.

Table 21 Increase in volume during cooking (per cent)

Containers	Storage period (month)						Mean
	1	2	3	4	5	6	
Tin	23.0	22.6	22.3	21.9	20.8	20.6	21.8
Polythene pouch	22.8	22.5	22.4	22.2	21.8	21.9	22.2
Polyteraphthalate bottle	22.3	22.1	23.0	21.6	22.3	21.7	22.1
Plain glass bottle	22.4	22.0	22.8	20.1	21.2	20.2	21.7
Coloured glass bottle	22.0	21.9	22.4	20.3	21.9	20.5	21.5
Control	22.7	21.9	22.6	22.7	22.5	22.9	22.7
Mean	22.5	22.3	22.5	21.8	21.7	21.3	

F - 3986.64**
SE - 0.008
CD - 0.024

The percentage increase in volume noticed in the baked cakes ranged between 21.5 and 22.7 (Table 21). Among the baked cakes, the maximum increase in volume was found for the cake in which butter was used as fat. A decrease in the volume was noticed towards the end of storage period. The increase in volume in all the cases were significantly different.

Table 22 Effect of stored oil and the quality of cake with reference to crustyness (scores)

Oil stored in different containers	Storage period (month) 1	2	3	4	5	6	Mean
Tin	3.1	3.4	3.7	3.2	3.4	3.8	3.4
Polythene pouch	3.2	3.6	3.6	3.5	3.4	3.4	3.4
Polyteraphthalate bottle	3.8	3.7	3.4	4.2	3.8	3.4	3.7
Plain glass bottle	3.5	3.3	3.8	3.2	4.0	3.5	3.5
Coloured glass bottle	3.8	3.5	3.7	4.0	3.9	3.6	3.8
Control	3.4	3.6	3.7	3.2	3.9	3.2	3.5
Mean	3.4	3.5	3.6	3.6	3.7	3.4	

F - 0.91**
SE - 0.297
CD - 0.824
** Significant at 1% level

The mean scores for crustyness (Table 22) was between 3.4 and 3.8. The scores obtained for the cake made using the oil stored in tin and polythene pouch were on par (3.4). Similarly, the scores for the cakes made with oil in plain glass bottle and control were on par (3.5) ~~in the case of plain glass bottle and control~~. Storage did not show any influence on the crust formation in cake.

Table 23 Effect of stored oil and the quality of cake with reference to fluffyness (scores)

Oil stored in different containers	Storage period (month)						Mean
	1	2	3	4	5	6	
Tin	3.6	3.7	3.3	3.8	3.2	3.1	3.4
Polythene pouch	3.7	3.7	3.1	3.4	3.6	3.2	3.4
Polyteraphthalate bottle	3.5	3.4	3.7	3.8	3.6	3.1	3.5
Plain glass bottle	3.6	3.3	3.2	3.5	3.4	3.3	3.3
Coloured glass bottle	3.4	3.2	3.7	3.3	3.8	3.2	3.4
Control	4.3	4.0	3.8	3.8	3.9	4.0	3.9
Mean	3.6	3.5	3.4	3.6	3.5	3.3	

F - 0.51**
SE - 0.318
CD - 0.881
** Significant at 1% level

The mean scores in Table 23 depicted that there was no significant difference in fluffyness of cakes made with the oil stored in different containers. The scores were between 3.3 and 3.9. The highest score was for butter cake (3.9). Here also the score did not vary during the storage of 6 months.

Table 24 Effect of stored oil and the quality of cake with reference to spongyness (scores)

Oil stored in different containers	Storage period (month)						Mean
	1	2	3	4	5	6	
Tin	3.4	3.4	3.6	3.2	3.5	3.2	3.3
Polythene pouch	3.2	3.5	3.2	3.2	3.4	3.4	3.2
Polyteraphthalate bottle	3.7	3.4	3.6	3.5	3.4	3.3	3.4
Plain glass bottle	3.5	3.2	3.6	3.4	3.5	3.2	3.4
Coloured glass bottle	3.4	3.3	3.5	3.6	3.4	3.2	3.4
Control	3.6	3.4	3.7	3.2	3.4	3.3	3.4
Mean	3.5	3.3	3.6	3.3	3.4	3.2	

F - 0.12^{**}
SE - 0.365
CD - 1.011
** Significant at 1% level

In the case of spongyness of the cakes prepared, the cakes made with the oil stored in polyteraphthalate bottle, plain glass bottle, coloured glass bottle and control had mean scores which were on par (3.4) (Table 24). The cake made with the oil stored in tin had a score of 3.3 and that made with the oil stored in polythene pouch had a socre of 3.2. There was no significant difference among the mean scores obtained for each month.

Table 25 Effect of stored oil and the quality of cake with reference to springyness (scores)

Oil stored in different containers	Storage period (month)						Mean
	1	2	3	4	5	6	
Tin	3.4	3.1	3.9	3.8	3.7	3.6	3.5
Polythene pouch	3.6	3.6	3.6	3.5	3.4	3.4	3.5
Polyteraphthalate bottle	3.8	3.7	3.4	3.8	3.4	3.2	3.5
Plain glass bottle	3.5	3.8	3.2	3.5	3.7	3.6	3.5
Coloured glass bottle	3.7	3.7	3.3	3.6	3.8	3.4	3.5
Control	3.8	3.7	3.9	3.8	3.8	4.0	3.8
Mean	3.6	3.6	3.5	3.6	3.6	3.5	

F - 0.51**
SE - 0.303
CD - 0.840
** Significant at 1% level

The mean scores as shown in Table 25 indicated that the scores were on par (3.5) for all the cakes made with palmoil. The butter cake obtained the maximum score (3.8). The scores obtained for each month were comparable.

Table 26 Effect of stored oil and the quality of cake with reference to evenness in baking (scores)

Oil stored in different containers	Storage period (month)						Mean
	1	2	3	4	5	6	
Tin	3.7	3.8	3.9	4.0	4.0	3.8	3.8
Polythene pouch	3.6	3.7	3.9	3.8	4.1	4.2	3.8
Polyteraphthalate bottle	4.0	3.8	3.9	3.7	3.6	4.0	3.8
Plain glass bottle	4.1	3.9	3.8	3.6	3.7	3.8	3.8
Coloured glass bottle	3.9	3.8	3.6	3.8	3.9	4.0	3.8
Control	4.2	4.0	3.9	3.8	4.0	4.1	4.0
Mean	3.9	3.8	3.8	3.7	3.8	3.9	

F - 0.84**
SE - 0.178
CD - 0.493
** Significant at 1% level

The mean scores obtained for the evenness in baking of cakes are given in Table 26. The highest score was for butter cake (4.0). Here also there was no significant difference in the scores even after storage of 6 months.

4.3 Organoleptic changes

The major quality attributes of the product studied were appearance, colour, texture, taste, flavour and doneness.

Table 27 Mean scores for quality attribute - appearance

Containers	Storage period (month)						Mean
	1	2	3	4	5	6	
Tin	3.1	3.4	3.9	4.7	4.1	3.8	3.8
Polythene pouch	3.6	3.6	3.6	3.5	3.4	3.4	3.5
Polyteraphthalate bottle	3.8	3.7	3.4	4.2	3.8	3.4	3.7
Plain glass bottle	3.5	3.7	3.4	4.2	3.8	3.4	3.7
Coloured glass bottle	4.5	4.4	4.4	4.3	4.4	4.4	4.4
Control	4.8	4.7	4.9	4.7	4.8	4.9	4.8
Mean	3.8	3.9	3.9	4.3	4.1	3.9	

F - 1.351**
SE - 0.265
CD - 0.736
** - Significant at 1% level

The mean scores for the appearance of cakes ranged from 3.1 to 4.7 (Table 27). There was no significant difference between the scores for cakes made with oils stored in different containers. The cake made with butter (control) scored the highest (4.8). Among the cakes made with palmoil, the cake in which the oil stored in coloured bottle was used was found to be superior (4.4). The least score was for the cake made with the oil stored in polythene pouches (3.5). There was significant difference between the mean scores obtained for butter cake and palmoil cake.

Table 28 Mean scores for quality attribute - colour

Containers	Storage period (month)						Mean
	1	2	3	4	5	6	
Tin	3.6	4.7	3.6	3.4	3.8	3.8	3.8
Polythene pouch	2.8	3.7	2.8	3.4	3.6	3.5	3.3
Polyteraphthalate bottle	3.6	3.7	3.5	3.6	4.3	3.6	3.7
Plain glass bottle	3.4	3.5	3.5	3.4	3.8	3.4	3.5
Coloured glass bottle	4.4	3.5	4.4	4.0	4.3	4.3	4.1
Butter	5.0	5.0	5.0	4.0	5.0	5.0	4.9
Mean	3.8	4.0	3.8	3.8	4.1	3.9	

F - 2.149**
SE - 0.211
CD - 0.586
** Significant at 1% level

The data (Table 28) for colour of the cakes revealed that there was no significant difference among those made using palm oil, while the difference between butter cake and palm oil cakes were significant. The mean scores for palmoil cake ranged from 3.3 to 4.9. Butter cake had the highest mean score of 4.9. Cake made with the oil stored in coloured bottle had a mean score of 4.1.

Table 29 Mean scores for quality attribute - flavour

Containers	Storage period (month)						Mean
	1	2	3	4	5	6	
Tin	4.0	4.2	4.4	4.0	3.9	4.2	4.1
Polythene pouch	3.7	4.3	4.0	3.9	3.5	3.9	3.8
Polyteraphthalate bottle	3.9	3.8	4.2	4.0	3.5	3.6	3.8
Plain glass bottle	4.3	4.5	4.3	4.1	4.0	3.8	4.1
Coloured glass bottle	4.3	4.5	4.5	4.4	4.2	4.1	4.3
Butter	4.5	5.0	5.0	4.6	4.5	4.5	4.6
Mean	4.1	4.4	4.4	4.2	3.9	4.0	

F - 0.482
SE - 0.211
CD - 0.586

Table 29 revealed the mean scores obtained for the flavour of the cakes. There was no significant difference between the mean score obtained for palmoil cakes and butter cake. The mean scores obtained for the cakes ranged from 3.8 to 4.6.

Table 30 Mean scores for quality attribute - texture

Containers	Storage period (month)						Mean
	1	2	3	4	5	6	
Tin	3.7	4.1	4.0	4.5	4.5	3.1	3.9
Polythene pouch	3.5	4.2	3.7	3.4	4.2	3.3	3.7
Polyteraphthalate bottle	3.9	4.2	3.7	3.9	3.8	3.6	3.8
Plain glass bottle	4.1	4.3	3.8	3.9	4.0	3.1	3.8
Coloured glass bottle	3.9	4.3	3.5	4.1	4.1	3.6	3.9
Butter	4.7	4.8	4.6	4.7	4.8	4.7	4.7
Mean	3.9	4.3	3.9	4.0	4.2	3.6	

F - 1.289
SE - 0.222
CD - 0.617

The mean scores obtained for the texture of the cakes revealed that there was no significant difference among the cakes (Table 30). The scores ranged between 3.7 and 3.9. Eventhough the differences among cakes made with palm oil were not significant, the differences between control and treatments were significant. The control had a maximum score of 4.7.

Table 31 Mean scores for quality attribute - taste

Containers	Storage period (month)						Mean
	1	2	3	4	5	6	
Tin	3.8	4.3	4.3	3.7	3.8	4.1	4.0
Polythene pouch	3.6	3.8	3.4	3.5	3.5	3.7	3.5
Polyteraphthalate bottle	3.7	3.9	3.9	3.8	3.6	3.8	3.7
Plain glass bottle	4.0	4.3	4.2	4.2	3.4	4.2	4.0
Coloured glass bottle	4.1	4.5	4.4	4.4	4.4	4.5	4.3
Butter	4.8	4.8	4.7	4.8	5.0	4.6	4.7
Mean	4.0	4.3	4.1	4.0	3.9	4.1	

F - 1.817
SE - 0.208
CD - 0.578

A close examination of the data for quality attribute, taste (Table 31) indicated that the mean score for the cake made using oil stored in coloured bottles (4.3) and polythene pouches (3.5) were significantly different. For rest of the cases eventhough there was a slight difference, it was not significant. The taste of butter cake was preferred to the taste of palmoil cake. The mean scores ranged from 4.3 to 3.5.

Table 32 Mean scores for quality attribute - doneness

Containers	Storage period (month)						Mean
	1	2	3	4	5	6	
Tin	4.1	4.7	4.6	4.8	4.5	4.2	4.4
Polythene pouch	4.0	4.7	4.7	4.4	3.9	4.5	4.4
Polyteraphthalate bottle	4.5	4.7	4.3	4.7	4.1	4.2	4.4
Plain glass bottle	4.7	4.9	4.7	4.8	4.2	4.0	4.5
Coloured glass bottle	4.4	4.9	4.5	4.9	4.6	4.3	4.6
Butter	5.0	5.0	5.0	5.0	5.0	4.0	4.9
Mean	4.5	4.8	4.6	4.8	4.4	4.3	

F - 1.298
SE - 0.173
CD - 0.481

The mean scores for the quality attribute doneness for the cakes (Table 32) made with the oil stored in tin, polythene pouch and polyteraphthalate bottles were on par (4.4). The difference in scores were not significant in other cases. The scores ranged from 4.4 to 4.6

Table 33 Overall acceptability of cakes

Containers	Storage period (month)						Mean
	1	2	3	4	5	6	
Tin	3.5	4.2	4.1	4.2	4.1	3.8	3.9
Polythene pouch	3.7	4.0	3.7	3.6	3.6	3.7	3.7
Polyteraphthalate bottle	3.8	4.0	3.8	4.0	3.8	3.7	3.8
Plain glass bottle	4.2	4.3	4.3	4.2	4.2	4.2	4.2
Coloured glass bottle	4.0	4.2	3.9	4.1	3.9	3.6	3.6
Butter	4.8	4.9	4.8	4.7	4.8	4.7	4.7
Mean	4.0	4.2	4.1	4.1	4.0	3.9	

F - 74.345**
SE - 0.660
CD - 1.831
Significant at 1% level

The mean scores obtained for the overall acceptability of the cakes (Table 33) revealed that the cakes were comparable to the control. The scores ranged between 3.6 and 4.7. The difference in scores were not significant.

Discussion

DISCUSSION

Red palm oil is becoming increasingly important as an edible oil not only because of its comparatively lower price but also due to its nutritional advantages, especially in terms of Vitamin A and E. Under Indian context it becomes often necessary to store the oil for obvious reasons. Studies related to this aspect is scanty and meagre. This study entitled "Shelf life studies on red palmoil" was undertaken to investigate the feasibility of storing the red palmoil without significantly affecting its quality. Five types of containers were used to store the oil for a period of six months and the quality parameters were assessed every month. The results obtained are discussed under the following headings.

5.1 Physico-chemical changes

5.2 Changes in cooking qualities

5.3 Organoleptic changes

5.1 Physico-chemical changes

In this context the results obtained for the various characters studied like specific gravity, smoke point, moisture, acid value, free fatty acid content, fatty acid profile, peroxide value, β-carotene, Vitamin E and iodine value are discussed.

Specific gravity of oil stored in different containers did not vary significantly throughout the storage period of six months. Any change in specific gravity during storage is expected only if there is a chance of the oil getting contaminated by impurities. In this study since all the containers were sealed air tight, such a possibility was completely ruled out. The results also confirms this view.

Many studies have highlighted the relation between smoke point and acidity of the oil. The results obtained in this study also showed that as the free fatty acid content increases the smoke point decreases, that is, smoke point and free fatty acid content are inversely related. . Since all the samples had shown a decrease in smoke point it is presumed that the containers used had no influence in preventing the decrease in smoke point.

Parvatham *et al*. (1994) reported that smoke point of red palm oil decreased when heated for two, four and six hours. The decrease in smoke point of heated samples was due to an increase in concentration of free fatty acid on repeated heating. Augustin *et al*. (1987) had indicated that the decrease in smoke point was regarded to be primarily a consequence of the increase in acidity.

A study conducted by Chanderkanta and Manoranjankalia (1993) revealed that the smokepoint of rape seed oil, mustard oil, cotton seed oil, groundnut oil and ghee decreased with increasing number of frying. Greatest fall in the smokepoint was noted in the case of groundnut oil.

The desirable level of moisture for edible oils are less than 0.2 per cent. Presence of moisture leads to hydrolysis of fat resulting in release of free fatty acid and subsequent oxidation. An increase in moisture content was noticed in this study which might have led to the increase in free fatty acid content.

Acid value is a parameter used to determine the free fatty acid content of the oil. In general, the free fatty acid content increases as storage prolongs. Here also there is an increase in free fatty acid content. This may be due to the hydrolysis of fat because of the presence of moisture.

The free fatty acid content of oils increases with the number of hours of heating. This increase indicate the extend to which the triglycerides have hydrolysed and volatilised during heating (Parvatham, 1994). An increase in free fatty acid content during storage was also reported by Sarojini and Bhavani (1997).

In a storage study conducted by Jayalekshmy *et al.* (1996) by adding antioxidants it was found that the antioxidants did not have much protective effect on the development of free fatty acid content during storage.

NKpa *et al*. (1990) reported that among the crude palm oil samples stored in lacquered metal can, amber glass bottle, green glass bottle, ~~clear glass bottle~~ and clear glass bottle, the oil stored in clear plastic bottle had the highest free fatty acid content.

According to the specification of prevention of Food Adulteration Act (1954), the maximum limit of free fatty acid in edible unrefined vegetable oils is three per cent. This is because as the free fatty acid content increase more mineral salts will be formed thus hindering the absorption of minerals. As the oil is stored for long periods the fatty acids are hydrolysed resulting in the increase of free fatty acid content.

In this study there was significant difference in peroxide formation with respect to each container. The maximum increase was found in polythene pouches. Since the polythene pouches used for storage were not thick and were transparent, the air moisture barrier was less. This must have led to the entrapment of air and moisture into the pouches thereby triggering the peroxide formation. The increase in peroxide value in polyteraphthalate bottles may be due to the action of plasticiser materials present in the container. This indicated that when red palmoil is stored at household level, care should be taken to use containers of good quality. The plain glass bottles were fully sealed with a sealing cap and so there was lesser chance for moisture and air to interact with oil resulting in a lower peroxide value. The coloured glass bottles had the lowest peroxide value since it was protected against light and moisture.

Jayalekshmy (1996) reported that red palmoil stored for six months showed an increase in peroxide value. Oil stored outside showed an increase of two per cent whereas there was only 1.8 per cent increase in the sample stored in the dark. The change was significant from the fifth month.

Results of the study conducted by Chanderkanta and Manoranjankalia (1993) indicated a gradual increase in the peroxide value of oil with increased number of heating. In a study done by Parvatham *et al*. (1994) the increase in peroxide value was more in refined palm oil than in crude palmoil. NKpa *et al*. (1990) studied the effect of packaging materials on storage stability of crude palm oil and the results showed that none of the containers were preventive against peroxide formation.

The β-carotene content is inversely proportional to the length of storage period. As the storage period increases the B carotene content decreases. A loss of β-carotene content was observed throughout the storage period in this study. Polythene pouches were the containers which were most exposed to light, moisture and air. Maximum loss was seen in the case of these containers. Other containers exhibited better protective effect for carotene in the oil.

Arumughan *et al*. (1997) had reported that there was loss in carotene content when red palm oil was stored. The loss may be due to the oxidation of carotene.

The vitamin E or tocopherol content of the oil was lost during storage. The maximum loss was seen in polythene pouches. This may again be due to its exposure to light, air and moisture.

Both carotenoids and tocopherols have antioxidant properties (Terao, 1989). These constituents have a synergistic action ie. only one of these components act as antioxidant at a time. The results of this study indicated the synergistic action clearly. During the initial period of storage there was significant decrease in tocopherol content whereas during the final stage the loss was found in carotene content. This indicated that for the first few months tocopherds acted as antioxidants and later the property was exhibited by carotenes. As a result the tocopherol and carotene content are maintained without much loss to any one of them.

The iodine value of the samples in this study showed a slight decrease which was not statistically significant. The decrease in iodine value was related to the peroxide formation. This might be due to the formation of peroxides on the unsaturated linkages.

Parvatham (1994) reported a drastic decrease in iodine value after heating of oils. The decrease in iodine value measures the overall deterioration of oil during heating. Sarojini and Bhavani (1997) reported no significant change in iodine value during storage of red palmoil blends.

5.2 Cooking qualities

A baked product (cake) was made every month with the oil stored in the five different containers. Butter cake was kept as control for the comparison of the products. Baking is rather a slow method of cooking, but it has the advantage that large quantities of food can be cooked and the food is cooked evenly (Cameron, 1978).

The ingredients in the preparation of cake are flour, sugar, fat and egg. A weak flour is best for cakes as it gives a fine even texture. Sugar gives a cake a sweet flavour and improves texture. Sugar also adds colour to the crust and improves keeping quality. Fats make the cake mixture smooth and light thus contributing to volume by helping to accelerate the entrapment of air during mixing. Of the fats used in cake making, butter is the best (Cameron, 1978). Egg white assists in trapping air and in moistening the cake mixture, it also adds strength to the structure when it coagulates on baking. Egg yolk adds richness and colour.

The cooking time for the cakes were comparable whereas the increase in volume was significantly different for each cake. The maximum increase in volume was noticed in butter cake. This may be due to the quality of fat and also the aeration of the cake mixture during mixing.

Crustyness is a surface characteristic of cake. A cake is said to be crusty if its surface is dry, hard or coarse. The storage of oil did not affect the crust formation in cake.

Fluffyness is a soft and downy textural property. It is also said about products which are light and airy. The fluffyness of all the cakes made with palm oil were almost similar. Butter cake was found to be the most fluffy.

Products which has a consistency of sponge, is open, loose, elastic, porous, springy and has a pliable texture is considered as spongy. The cakes made with palmoil and butter had good spongyness.

An elastic surface texture such as that of a freshly baked bread is called springy. Butter cake was the most springy among the cakes prepared. There was no significant difference in the evenness in baking of the cakes.

5.3 Organoleptic changes

Sensory quality is one of the criteria for acceptability of any food product by the consumer (Jellnick, 1986). Moreover the sensory evaluation of the food is assumed to be increasing significance, as this provides information which may be utilised for development of a product and its improvement. Sensory quality has also been defined as the degree of excellence or fitness for eating in those contributory attributes which are perceived through the senses of sight, smell, taste, touch and hearing (Land, 1983).

The appearance of an object is a combination of the visually perceived information contained in the light reflected, transmitted and its colour. According to Christensen (1985) as the consumer's preference to appearance is one of the major factors leading to the increasing demand of the product, it is very essential to keep te appearance of the product very attractive. The appearance of cake made using palmoil was comparable to that of the butter cake.

Colour is associated with every aspect of our life and influences many of our day to day decisions, involving food. According to the reports from CFTRI (1990), the aesthetic, sensory characteristics and acceptability of food are all affected by colour. Clysdesdale (1979) stated that colour affect the sensory characteristics, such as sweetness, salt and flavour. The joint FAO/WHO expert committee on food additives recognised that colour has an effect on food choices (Anonymous, 1991).

The first impression of food is usually visual and major part of our willingness to accept a food depends upon its colour (Jellnick, 1986).

The cake made with palmoil had an orange red colour due to the high carotene content of the oil. Butter cake had a cream colour. Since the colour of palmoil cake does not suit the conventional colour of cakes we should try blends of red palmoil and other vegetable oils so that the intensity of the oil colour can be lowered. A blend of red palmoil and groundnut oil at a ratio of 1:1 was found to be acceptable in various snacks (Manorama, 1992).

Flavour is the unique character of odour and taste. Appearance of the food is important but it is the flavour that ultimately determines the quality and acceptability of foods. Renganna (1986) stated that flavour is an important factor which enriches the consumer's preference to a particular product. The flavour of processed foods is probably the most important single quality factor of concern to the food technologist.

The flavour of the cake made with palmoil was well accepted and comparable to butter cake.

Texture, tenderness, crispness and firmness are some of the more important attributes of quality in foods (Gould, 1977). Ranganna (1986) stated that texture is the property of food which is associated with the sense of feel or touch experienced by the finger or the mouth. The results of sensory evaluation reveals that the texture of palmoil cakes were comparable to the control.

According to Rolls (1981) in the various quality attribute tested, the first preference goes to the taste. Taste is the major attribute which determines the acceptability of food material.

Inspite of the increase in the peroxidation of the oil the scores for taste were satisfactory. This may be because the taste of palmoil was covered by the taste of butter. There was a raw taste in palm oil which did not affect the acceptability of the product.

The cakes made with palmoil were well cooked. This shows that the oil is suitable for the preparation of baked products.

Summary

SUMMARY

The study entitled "Shelf life studies on red palmoil" was conducted to ascertain the physico-chemical and organoleptic changes taking place during the storage of red palmoil in different containers.

Oilpalm which is the largest oil yielding crop has been recommended by Technology Mission on Oilseeds as an alternate source to meet the edible oil demand of our country. Red palmoil is extracted from the mesocarp of the oilpalm fruit. The unrefined red palmoil is deep red in colour due to the high carotene content. Through this study an effort was taken to assess the extend of deterioration that occurs in the oil during storage and also whether the storage containers has any role in reducing the rate of deterioration.

The study was conducted for a period of six months. The containers used for storage were tin, polythene pouches, polyteraphthalate bottles, plain glass bottle and coloured glass bottles. Six sets of each container were kept so that the container once used need not be reused. The analysis were done in order to ascertain the physico-chemical changes such as specific gravity, smokepoint, moisture, acid value, peroxide value, β-carotene, Vitamin E, iodine value and fatty acid composition. These analysis were conducted every month and a baked product (cake) was also prepared using this oil.

The specific gravity did not vary throughout the storage period. This is a parameter which do not change unless any impurity is added to the oil. A significant increase in the moisture content was seen in the stored oil samples. This was one of the reason why an increase in peroxide value was found.

Acid value which is a parameter used to calculate the free fatty acid content of the oil increased throughout the storage irrespective of the container in which the oil was stored. It was seen that the free fatty acid content did not increase considerably till the third month. The free fatty acid content crossed the desirable limit of three per cent for edible oils. Peroxide value also increased significantly in all the containers. The maximum peroxide value was recorded for the oil stored in polythene pouch. This was due to the exposure of the container to light and air thus leading to the entrapment of moisture into the pouches. Peroxide value and iodine value are inversely related. As the rate of peroxidation increases the iodine value shows a slight decline which has happened in this study.

Smoke point was another characteristic which changed significantly. Many studies have reported that the increased acidity of the oil reduces the smoke point of the oil. Similar results were obtained in this storage study. Storage period or storage containers did not have any influence on the fatty acid composition of the oil.

Red palmoil is unique for its high carotene and tocopherol content which are known for their antioxidant property. They exhibit synergistic action. For the first few months the tocopherol content decreased whereas the oil was protected by the carotenes during the last months of storage. About 50 per cent loss was noticed in both the nutrients from the polythene pouches. Eventhough loss was recorded from all containers it was least from the coloured glass bottles.

The odour and taste of the stored oil samples were done every month. The fruity odour and tart taste of red palmoil made it less acceptable. But it was interesting to note that the acceptability of the oil remained almost same throughout the storage period. This indicates that the oil has not turned rancid to a detectable level.

The cooking qualities of the baked product was also assessed. There was no significant change in the cooking time of the cakes. The increase in volume was significantly different for each cake and a slight decrease in volume was seen during the end of the study. The cakes were crusty, spongy, fluffy, springy and evenly baked. The cake made with butter was superior in all the qualities than the cake made with palmoil.

The organoleptic evaluation of the product revealed that it was comparable to butter cake in all the quality attributes like appearance, colour, texture, taste and doneness.

The study revealed that red palmoil can be stored only for three months without much deterioration irrespective of the type of container used for storage. Maximum deterioration in oil quality was found in polythene pouches due to the exposure to light, air and moisture. Coloured glass bottles can be recommended as the best container to store red palmoil without much loss of nutrients for which it is unique.

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Appendices

APPENDIX - I

SCORE CARD FOR ASSESSING THE COOKING QUALITIES OF CAKE

Quality grade description	Scores	T_1	T_2	T_3	T_4	T_5	T_6
Crustyness							
Excellent	5						
Very good	4						
Good	3						
Fair	2						
Poor	1						
Fluffyness							
Excellent	5						
Very good	4						
Good	3						
Fair	2						
Poor	1						
Spongyness							
Excellent	5						
Very good	4						
Good	3						
Fair	2						
Poor	1						
Springyness							
Excellent	5						
Very good	4						
Good	3						
Fair	2						
Poor	1						
Evenness in cooking							
Excellent	5						
Very good	4						
Good	3						
Fair	2						
Poor	1						

APPENDIX - II

EVALUATION CARD FOR TRIANGLE TEST

In the triangle test three sets of sugar solution of different concentration were used. Of the three sets two solutions were of identical concentrations and the members were asked to identify the third sample which was of different concentration.

Name of the product : Sugar solution

Note : Two of the three samples were identical, identify the odd sample

Sl. No.	Code No. of the samples	Code No. of the identical samples	Code No. of the odd sample
1	XYZ		
2	ABC		

Signature

APPENDIX - III

SCORE CARD FOR ASSESSING THE ORGANOLEPTIC QUALITIES OF CAKE

Quality grade description	Score	T_1	T_2	T_3	T_4	T_5	T_6
Colour							
Cream	5						
Yellow	4						
Yellow orange	3						
Orange	2						
Red	1						
Appearance							
Excellent	5						
Very good	4						
Good	3						
Fair	2						
Poor	1						
Flavour							
Aromatic	5						
Acrid	4						
Burnt	3						
Doughy	2						
Fest	1						
Texture							
Very soft	5						
Soft	4						
Sticky	3						
Hard	2						
Brittle	1						
Taste							
Ambroisal	5						
Pleasant	4						
Alkaline	3						
Rancid	2						
Bland	1						
Doneness							
Well cooked	5						
Cooked	4						
Partially uncooked	3						
Moderately uncooked	2						
Raw	1						

Note:

Acrid - Sharp and harsh odour, bitterly pungent

Aromatic - Possessing fragrance, slightly pungent aroma usually pleasant

Flat - Having little or no flavour

Ambroisal - Exquisitely pleasing in taste or smell delicious

Abstract

SHELF LIFE STUDIES ON RED PALM OIL

By

ARCHANA. U.

Abstract of the thesis
submitted in partial fulfilment
of the requirement for the degree of
Master of Science in Home Science
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DEPARTMENT OF HOME SCIENCE
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM

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ABSTRACT

The study entitled "Shelf life studies on red palm oil" is a comprehensive study carried out with an objective to assess the qualitative changes of red palm oil during storage.

Red palm oil is extracted from the mesocarp of oilpalm fruit which is deep red in colour due to its high carotene content. The storage study was planned for six months. The oil was stored in tins, polythene pouches, polyteraphthalate bottles, plain glass bottles and coloured glass bottles. The analysis carried out to ascertain the physico-chemical changes in the oil were specific gravity, smoke point, moisture, acid value, fatty acid composition, peroxide value, β-carotene, Vitamin E and iodine value. The samples were drawn out every month and analysed. A product (cake) was also made every month.

During storage there was a visible increase in acid value and peroxide value and a decrease in smoke point. Loss in carotene and tocopherol content ~~was~~ were also noticed. There was no significant change in specific gravity and iodine value. The deterioration in oil quality and loss of nutrients were found to be directly related to the rate of exposure of the container to light, air and moisture.

The cooking qualities and organoleptic evaluation of the product (cake) indicated that it was acceptable and comparable with that of butter cake.

The best container which can be recommended for the storage of red palm oil is coloured glass bottle. While storing oil in other containers it is advisable to keep the containers in dark so that there is little exposure to light.