STUDIES ON THE COMPOSITION, STORAGE AND ACCEPTABILITY OF SUNFLOWER OIL

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In Partial Fulfilment of the requirements
for the Degree of
Master of Science (Home Science)

BY

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CERTIFICATE

This is to certify that the thesis entitled "Studies on the composition, storage and acceptability of sunflower oil" submitted for the Degree of Master of Science, Home Science, Andhra Pradesh Agricultural University, is the result of bonafide research work carried out by Miss. Ch. Parvathi, under my supervison, and that the thesis has not formed in whole or in part of the basis for the award of any degree, diploma or similar distinction.

The assistance and help received during the course of the investigation have been duly acknowledged.

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Major Advisor

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INTRODUCTION

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It has been well recognized that calorie deficiency is one of the major nutritional problems among the vulnerable population of India. Studies carried out in several parts of the country, indicate that the protein deficiency in the vulnerable population is partly due to the calorie deficiency in the diet. This being so, even when adequate quantities of proteins are present in the diet, they are being diverted for the uneconomical calorie production, thereby creating a 'conditional protein gap'. By providing a cheaper source of energy, either by increased cereals or fats in the diet, the proteins can be spared.

The consumption of large quantities of cereals in order to meet the calorie requirements is rather difficult, more so by the children. But consumption of adequate quantities of vegetable oils is possible by all age groups, as vegetable oils are a more concentrated source of energy than cereals. Apart from this, vegetable oils help in the absorption of fat soluble vitamins and provide the essential fatty acids which are required to maintain the integrity of the skin and growth of the body. Thus our main hope in bridging the calorie gap lies in raising the oil production of our country.

The area under oilseed cultivation in India is 16 million hectares. The edible oilseeds cultivated being - groundnut, safflower, sesame, rapeseed, mustard and coconut. *The production of the oilseeds from the past two decades is 5.1 million tons in 1950-51, 5.7 million tons in 1955-56, 7.0 million tons in 1960-61, 6.4 million tons in 1965-66 and 7.6 million tons in 1966-70. The current oilseed production being 9 million tons. **9-13% of the calories are derived from fats and oils sources, whereas cereals contribute 50-70 per cent of the calories in the Indian diet. In India the average per capita availability of fats and oils is only 12 g/day as compared to the I.C.M.R. recommended allowance of 40 g/day. This low consumption level may partly be due to the high cost of the oils and partly due to their low production levels. ***In order to make up this deficit in the past three years about 38,000 tons of edible vegetable oils have been imported. But in order to attain self-sufficiency in vegetable oils, there is an urgent need to increase the present rate of production markedly. But this is not possible with the low yielding traditional oilseed varieties. Thus a need for the cultivation of a new, cheaper, high yielding and short duration oilseed

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*Earle, F.R., Vanetten, C.H., Clark, T.F. and Wolff,I.A. Composition data on sunflower seed, Northern Regional Research Laboratores, Peoria, Illinois, 61604.

**Viswera Rao, K.: J.Nutr.Diet. (1967) 4, pg. 79.

***Banerji, Sushidal: India still needs to import vegetable oils. Soyabean Digest. Oct. 1972.

variety has arisen. This brings into focus, two oilseed crops - soyabean and sunflower (Helianthus annus). Of these two crops, the cultivation of sunflower is more suitable for the Indian climates. Further, soyabean is cultivated more for its protein content rather than for its oil contribution.

Sunflower has probably increased in the importance faster than any other oil source. The increased activity in production and export of sunflower seed and oil has occurred primarily in Soviet Union. But it is also cultivated to a large extent in other countries such as Spain, France, Rumania, Hungary, Argentina, Bulgaria, Mexico, United States and Canada. *Around 1962 and 1967, the world production of the oil expanded by nearly 60%, the amount produced surpassed peanut, cotton seed and coconut oils, to climb from fifth to second place among the vegetable oils of the world. The first place being claimed by Soya bean oil. The amount of sunflower oil produced in world in 1972 totalling upto 9386 million metric tons.

It is advantageous to introduce sunflower in Indian cultivation as it requires only 80-100 days for harvesting, as against 120-140 days for groundnut and safflower. It is a high yielding variety, yielding 10 q/ha as compared

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* Earle, F.R., Vanetten, C.H., Clark, T.F. and Wolff, I.A.: Composition data on sunflower seed. Northern Regional Research Laboratories, Peoria, Illinois, 61604.

to only 5 q/ha in dry land areas. Further, the oilseed meal is a good source of protein.

In order to introduce any oil into the market, it is first essential to know its composition, storage and acceptability. Thus an attempt has been made to study the composition, storage and acceptability of sunflower oil. The composition of sunflower oil is reported to vary with the type of environment in which it is cultivated. Therefore the composition and chemical characteristics of sunflower oil from Hyderabad was studied using sunflower oil from Canada as a standard. Since groundnut oil is popularly used among the masses, the composition, storage and sensory evaluation of sunflower oil was determined in relation to groundnut oil.

In developing countries, such as in India, where tradition is deeply ingrained, people will not buy a new food product, simply on the strength of its low cost, higher nutritional qualities and other merits. It is incorrect to think that poor people will accept any food. Therefore when a new food is introduced in the market, it should smoothly fit into the existing and established food practices of the people. Since sunflower oil has been recently introduced in India an attempt has been made to study the consumer acceptability of sunflower oil as a cooking medium.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Most of the research work in sunflower oil has been conducted in Russia, the information therefore being reported mainly in Russian journals, which were not available. Thus very little information regarding the fatty acid composition and chemical characteristics of sunflower oil has been reviewed here. No work regarding the storage properties or sensory qualities of sunflower oil was obtained. Thus the storage properties of other oils and the principles of sensory evaluation have been briefly reviewed here.

FATTY ACID COMPOSITION AND CHEMICAL CHARACTERISTICS:

National Institute of Nutrition, Hyderabad, (1972) reported the nutritive value for 100 g sunflower seed as indicated in Table 1.

Table 1: NUTRITIVE VALUE OF 100 g SUNFLOWER SEED

Protein	..	19.8 g
Fat	..	52.1 g
Carbohydrates	..	17.9 g
Calories	..	620
Calcium	..	280 mg
Iron	..	5 mg
Thiamine	..	0.86 mg
Riboflavin	..	0.20 mg
Niacin	..	4.5 mg

*Severalinvestigators have reported that the oil content of sunflower seed ranges from 22-36%. The seed kernel contains albumin (15-32%), globulin (46-48%), glutelin (8-19%) and insoluble protein. Barker and Hilditch (1950) studied the influence of environment upon the composition of sunflower oil. They analysed the fatty acid composition in ten sunflower seed oils produced in various regions of Africa. They reported that large variations occurred in linoleic and oleic acid in different oils. The content of linoleic acid ranged from 44-72% and that of oleic acid 14-34%. They said that the reasons for variation may be due to different varieties of sunflower or due to different environmental conditions during the growth of the plants and ripening of seeds.

Eckey, E.W. (1954) reports that sunflower oil is light yellow in color, and is well suited for use as a salad oil and cooking oil and when hydrogenated for use in margarine and shortening. According to him the composition of the oil and iodine value was influenced not only by the variety grown, but also by the environment, including such factors as temperature, soil fertility and moisture supply. Oils differing

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* The Wealth of India - A dictionary of Indian Raw Materials and Industrial Products Raw Materials, Vol.5 - H-K (1959).

from each other widely in iodine number, differ in composition mainly in the ratio of linoleic to oleic acid.

Robertson et al,(1971) analyzed the chemical composition of the sunflower hybrids grown at different locations in South Africa. He reported that all the varieties were relatively low in palmitic and stearic acids. Small amounts of palmitolenic, linolenic, arachidic, behenic and lignoceric acids were present in all samples. Linoleic acid and oleic acid together made up 86.8%-91.3% of the fatty acid composition of oils. Oleic acid ranged from 33.4%-62.7% and linoleic acid ranged from 27.3%-54.2%. The oil of the sunflowers grown at warmer locations and at lower latitudes had a lower linoleic acid content than those grown in comparatively cooler locations and higher latitudes.

Eric.D.Putt (1966), analyzed the fatty acid composition of sunflower oil of different varieties, grown in different locations in Canada. No great variation in the fatty acid composition between varieties was reported.

Jamieson and Baughman (1922), Hilditch, T.P.(1944), Williams, K.A.(1950), Vidyarti (1951), Hilditch, T.P.

(1956), Eckey, E.W.(1959), Eric D.Putt,(1966) Cummins (1967), Theodore, J.Weiss (1970), have reported the fatty acid composition and chemical characteristics of sunflower oil which is given in table 2. The range in the composition of sunflower oil as reported by these investigators is as follows:

Palmitic acid	..	3.5-9.6%
Stearic acid	..	1.6-5.0%
Oleic acid	..	14.3-46.9%
Linoleic acid	..	43.5-75.4%
Linolenic acid	..	0-0.3%

The range of the chemical characteristics of sunflower oil is as follows:

Iodine value	..	113-136
Saponification value	..	188-195
Unsaponifiable matter	..	0.3-1.5
Acid number	..	0.6-2.4
Refractive index	..	0.920-1.484
Specific gravity	..	0.920-0.926

STORAGE PROPERTIES OF SUNFLOWER OIL:

Keeping qualities of fats and oils are affected by air, moisture, light, oxygen concentration, temperature and metals. Very few reports were available

TABLE 2: FATTY ACID COMPOSITION AND CHEMICAL CHARACTERISTICS OF SUNFLOWER OIL

% fatty acid composition and chemical characteristics	Jamieson &Banghman (1922)	*Pieraetes (1944)	*Eibner (1944)	Williams,K. A.(1950)	Vidyarti (1951)	Hilditch,T. P.('56)	Eckey E. W. (1959)	Eric.D. Putt (1966)	Cummins (1967)	Cummins (1967)	Theodore J. Weiss (1970)
Source of oil	Argentina	Congo	Russia	-	-	United States	-	Canada	Canada	Russia	-
Saturated acids	4.8	-	-	5-13	-	0.1	9.7-12.8	-	-	-	-
Palmitic acid	6.4	3.7	9.6	-	-	6.5	-	5.98	6.6	5.6	6
Stearic acid	1.3	1.6	1.6	-	-	3.0	-	4.31	1.7	3.2	5
Oleic acid	21.3	42.0	36.2	25-42	-	44.2	21.2-39.1	18.09	29.3	46.9	21
Linoleic acid	66.2	52.0	54.2	52-66	-	44.0	51.2-68.3	71.56	61.8	43.5	66
Linolenic acid	-	-	-	-	-	-	0.1%or less	-	0.3	0.2	-
Iodine value	139.3	-	-	133.4	125-126	-	113-142.9	110.00	-	-	125-136
Saponification value	-	-	-	191.2	188-194	-	190-191.6	-	-	-	189-194
Refractive index	-	-	-	1.472	-	-	1.4709-1.4749	-	-	-	1.4663-1.4840
Specific gravity	-	-	-	0.925	0.920-0.926	-	-	-	-	-	0.920-0.926
Unsaponifiable matter	-	-	-	0.75	Below 1.5	-	0.3-1.3	-	-	-	0.3-1.5

* Cited from the Chemical Constituents of Natural Fats, Hilditch, T.P. (1944)

on the shelf life of sunflower oil. The changes during storage being nearly the same for all vegetable oils, with perhaps a difference in the induction period and the break down products of fat hydrolysis. Therefore, the storage properties of other oils is briefly reviewed here.

Markova, et al.,(1964) studied the behaviour of unsaturated fatty acids in sunflower oil, soya oil and rapseed oils heated to 300°C for 5, 10, 15 and 30 minutes. Linoleic and linolenic acids were estimated before and after heating. Linoleic acid values fell with time of heating, relatively little in sunflower oil and markedly in soya oil. In sunflower oil and not in the other two oils, linolenic acid values increased with time of heating. There was no significant difference in results between heating on a gas flame or on a cooking plate.

Alan et al., (1963) studied the chemical composition of various oils before heating and after heating to 495°F for 40 minutes. In case of groundnut oil he found that there was a decrease in the unsaturated fatty acids linoleic - 3.3% and linolenic - 1.10% and increase in the saturated acids by 3.28% after heating.

Thompson, J.A., et al. (1967) did a survey of fats and oils commercially used for deep fat frying

and found that the degree of deterioration is independant of their degree of unsaturation, but rather depends on how they are used. The degree of increase in viscosity, color, free fatty acids and peroxide value and the decrease in iodine number and unsaturated fatty acids indicated that some food processors maintain their frying oils in good quality while others abuse and damage theirs. The fatty acid composition of the used fat and oil samples as analysed by gas chromatography do not add up to 100% and in severely damaged oil reached only 84%. This probably is due to the presence of polar and polymeric fatty acids which cannot be eluted under the normal conditions for analysis.

Lois Kilgore, et al., (1970) reported that at high temperatures, such as those required for deep fat frying foods, cause chemical changes in fat. These changes occur more readily in unsaturated fats and include oxidation, polymerization and degradation. The linolenic acid percentage before heating potato chips for 6 hours it was found to be 72.0% and after frying 10 lbs of the same was found to be 69.6%. Thus the percentage loss of linoleic acid after frying was 2.8%.

The Indian Central Oilseeds Committee (1952) studied the keeping quality of groundnut oil stored for 11 months. Peroxide value and acid number were used

to determine the degree of deterioration. Acid number of the oil at the commencement of the experiment was 1.68, after 3 months it was 2.1 and continued to be so for another 3 months. At the end of the experimental period of 11 months the acid number was 2.9. The peroxide value of the groundnut oil initially was 4.99, after 3 months it was 14.6, after 6 months it was 27.0 and at the end of the experiment the value was found to be 45.1.

Kehra and associates (1956) studied the chemical constants of groundnut oil before heating and after heating for 2 hours. The acid value was 3.3, saponification value - 189.5, iodine number 86.4 and R_M value 0.44 before heating and after heating the values were 2.1, 188.2, 85.6 and 0.22 respectively.

Perkin and Van Akkeren*(1970) have shown that intermittent heating of fat alternated with cooling cycles increased the deterioration of cotton seed oil as judged by peroxide value. Furthermore, they reported that the method of cooking oils in India had an adverse effect on their nutritive value.

D.C.Jain and S.L.Mehra (1966), studied the keeping quality of groundnut oil. They have reported that the difference in the inductive period of samples of crude and refined oils from the same batch was very

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* J.A.D.A. 1970, Vol.56, pg. 130.

little, showing thereby that while the refining process may lower the acidity and make the oil more agreeable as regards taste and odor, it did not appreciably improve the keeping quality. According to them a raw vegetable oil is better than its refined product which in turn is better than the hydrogenated product in many respects such as nutritive value and keeping quality.

Vimala Devi (1971) conducted an experiment on the nutritive value of used oils and dalda and reported that the acid number and the percentage increase of acid number of groundnut oil, safflower oil and dalda were maximum in the oils exposed to heat for 3 hours. The acid number of fresh fats was found to be 0.64, 1.1 and 0.11 in case of groundnut oil, safflower oil and dalda respectively and corresponding acid number in three hours fried samples were found to be 1.20, 1.62 and 1.19. The percentage increase in acid number between fresh and three hours fried fats were found to be 87.5, 47.3 and 72.7 in groundnut oil, safflower oil and dalda respectively.

Jain, D.C. and Mehra, S.L.(1966), in a study of the storage behaviour of raw, refined and hydrogenated groundnut oils reported that in an experiment conducted by the Ministry of Foods on the storage behaviour of 3 varieties of groundnut oil - raw, refined and hydrogenated oil samples were stored in

two types of containers - ordinary cigarette tins and glass bottles. The tins and bottles were thoroughly cleaned and dried before they were filled with the oil samples. Throughout the period of observation all of them were kept in the dark, thereby eliminating the effect of light. Two temperatures - normal temperature which ranged between 34° ± 6°C and 50° ± 1°C maintained in an incubator to observe the accelerated effect on the storage behaviour at the elevated temperature. Peroxide value and acid value were used to assess the degree of deterioration of oils. Deterioration was higher in tin containers than for the corresponding samples stored in glass containers. The rate of deterioration was found to be higher in refined groundnut oil and at elevated temperatures rather than in raw or hydrogenated oils and at room temperatures.

Nageswara Rao and Narsinga Rao (1968), studied the effect of heating on fats and oils due to cooking. The fats and oils studied were groundnut oil, refined groundnut oil, hydrogenated groundnut oil, ghee, lard, coconut, safflower oil, refined safflower oil and sesame oil. Each day oil was heated in a frying pan for 1 hour, keeping the temperature at 180°C. During this period 200 g of potatoes and 25 papad were heated. The same procedure was repeated on four consecutive days.

Iodine value, peroxide value, acid value and refractive index were determined for the raw and heated samples to determine the degree of deterioration of oils. Iodine value of all the fats and oils decreased with the number of times of heating. The changes were more marked in groundnut oil and sesame oil. Changes in peroxide value were more marked than either iodine value or acid number. Peroxide value increased only slightly on heating for groundnut oil and sesame, which had a high peroxide value to begin with. Acid value of groundnut, sesame and safflower with higher acid value initially were not affected by heating to a large extent. Ghee, lard, hydrogenated oils, refined groundnut oil and refined safflower oil, all of which had a low acid value to begin with, showed a consistent increase in acid value. No changes in the refractive index of oils due to heating were observed.

Arya et al.(1972), reported on storage properties of refined groundnut oil as a substitute for hydrogenated oil. They observed the chemical changes in refined groundnut oil when used for frying at 180°C, 220°C and 260°C for 2 hours, 4 hours and 6 hours. Poories made from 9.51 kg of wheat flour dough was used for frying in 5 kg oil for 6 hours continuously. Peroxide value, free fatty acid as a percentage of oleic acid and iodine value were used to assess the degree of rancidity of the oil. Table 3 shows peroxide value, acid number and iodine value of initial oil and fried oil

for four hours and 6 hours.

TABLE 3: PEROXIDE VALUE, ACID NUMBER AND IODINE VALUE OF HEATED REFINED AND HYDROGENATED GROUNDNUT OIL

Period of frying	Temperature of frying	Peroxide value (meq peroxide/kg oil) ± .5		Acid value ± .2		Iodine value ± .3	
		Refined	Hydrogenated	Refined	Hydrogenated	Refined	Hydrogenated
Initial	180°C	7.4	2.2	0.09	0.09	91.4	70.1
	220°C	7.6	2.4	0.09	0.06	91.4	69.5
	260°C	10.1	2.7	0.08	0.09	91.4	70.3
6 hours	180°C	12.2	12.4	0.15	0.18	86.7	66.7
	220°C	12.7	13.5	0.18	0.21	83.5	64.2
	260°C	14.1	15.2	0.23	0.32	80.5	61.9

At the commencement of the experiment the peroxide value was 7.4, 7.6 and 10.4 for refined groundnut oil samples and 2.2, 2.4 and 2.7 for hydrogenated samples both heated to 180°C, 220°C and 260°C. Acid value was about 0.90 for both refined and hydrogenated samples. Iodine value was 91.4 for all groundnut oil samples and about 70 for all hydrogenated samples.

After 6 hours heating the peroxide value increased to 12.2, 12.7 and 14.1 for groundnut oil samples and 12.4, 13.5 and 15.2 for hydrogenated samples heated

to 180°C, 220°C and 260°C. The acid value increased by 0.18 for groundnut oil sample and by 0.2 in case of hydrogenated sample. There was a decrease in the iodine value after 6 hours frying by about 7.9 in case of groundnut oil and 8.1 in hydrogenated samples. From these observations they reported that there was a greater increase in the peroxide value and acid number of the oil sample whereas the decrease in the iodine value was greater in hydrogenated samples than oil samples. Thus the levels of unsaturation of groundnut oil being higher, it deteriorated at a faster rate than the hydrogenated sample.

Paul et al., conducted an experiment to study the storage property of ghee with special reference to the types of containers used for storing the same. Glass, porcelain, aluminium and tinned iron were found to be good, as judged by the peroxide value while mud-pot, brass and bronze were found to be bad so far as the storage quality of ghee kept in them was concerned. Aluminium was found to be the best of all the containers.

SENSORY EVALUATION

No literature regarding the sensory evaluation of sunflower oil or any other oil was available. Because of acceptance of fats and oils already in use over generations of years, perhaps the need for sensory evaluation did not arise. Thus the principles of sensory evaluation

and consumer acceptability are briefly considered here.

Success of any food product depends on the acceptance by the consumer. According to Govindarajan (1971), consumer reactions are difficult to measure since acceptance and selection of food is conditioned by many complex factors such as attributes of food and attributes of the consumer. Food attribute consists of four aspects - the hidden attributes i.e., the nutritional factors, anti-growth factors and toxins; the quality and economy attributes i.e., the total production, availability, price convenience, etc.; the sensory attributes, i.e.; the color, appearance, texture, taste, aroma, etc.; the effective attributes i.e., the likes/dislikes and preference/avoidance of foods. The first three attributes are that of food and thus the desirable components can be preserved and undesirable products eliminated by science and technology. The fourth attribute is that of consumers and thus covers a large number of factors, such as regional preferences, nationality, race, age, sex, religion, education, experience, socio-economic grouping, physiological and psychological motivations. The interactions of many of these factors with food results in the vastly different food patterns, likes/dislikes and preference/avoidance. The lack of control over the above makes the prediction of success of novel foods with any degree of confidence difficult.

Thus subjective methods of sensory evaluation of food under controlled conditions in the laboratory with trained group of judges during all the stages of research and product development is important.

Consumer acceptance is essentially weighted with considerations of cost along with traditional food purchase and cooking procedures, group conformance and deep rooted religious restrictions.

According to Govindrajan, greater possibilities of success with new food is likely when:

1) The management and Government are convinced of worth of new foods.
2) Sensory evaluation of foods is conducted.
3) Experienced campaigners, who are convinced of the merits of the product that they are manifestly eating it themselves.
4) Product is introduced to selected group of the consumer public who are innovators and better if they are local society leaders.
5) Product is introduced by privileged rather than under-privileged group.
6) New food fits into the culinary pattern of the consumers.

7) Sensory properties of the normal foods, into which the new foods are introduced, should not be affected.

Finally, Govindarajan, et al (1971) concluded that "so long as man eats his food and not nutrition, his heads and acceptance will remain the prime criteria for success of new foods".

MATERIALS AND METHODS

MATERIALS AND METHODS

Sunflower seeds (Helianthus annus) were procured from the Dryland Project, I.C.A.R., Hyderabad. The sunflower seed variety used was E.C. Armaveric also called E.C. 68415. It was a kharif crop planted in August and harvested in mid-October. Oil was extracted in the local oilseed ghana, in the normal procedure applied to any edible oilseeds. Fresh groundnut oil was obtained from the same source. Sunflower oil with a trade name "Safflo" was obtained from Canada.

Sunflower oil sample used for consumer acceptability studies was stored in an oil tin at room temperature. The rest of the oil samples were stored in a glass container at refrigeration temperatures throughout the period of investigation.

The methods used in the present investigation consist of four aspects, namely - fatty acid composition and chemical characteristics, storage properties, sensory evaluation and consumer acceptability.

Fatty acid composition was determined by gas-liquid chromatography. Iodine number, refractive index, were used for determination of chemical characteristics. Peroxide value and acid

number were used to assess the degree of rancidity of oils. The method of scoring employed for sensory evaluation was descriptive scoring and successive rating scale based on the principle of hedonic scale. The consumer acceptability of sunflower oil as a cooking medium, was carried out using the questionnaire method.

FATTY ACID COMPOSITION AND CHEMICAL CHARACTERISTICS

1. ESTIMATION OF FATTY ACIDS BY GAS-LIQUID CHROMATOGRAPHY

PREPARATION OF FREE ACIDS AND ESTERS:*

Free fatty acids were prepared by saponifying the fat with five times its own weight of 6% alcoholic potassium hydroxide, for three hours. The alcohol was evaporated and the resultant soap was dissolved in water. The soap was then split with 1:1 hydrochloric acid until the medium changed to acidic. The extract was washed with distilled water to make it acid free. The solvent was made moisture free by the addition of anhydrous sodium sulphate. Methyl esters were prepared by refluxing the fatty acid mixture in four times its own weight

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* Rodolfo Paolith and David Kritcheosky (1963). Advances in lipid research. Academic Press. New York and London.

of methanol with the addition of 1% concentrated sulphuric acid. The acid was removed in the repeated washings. The methyl esters were obtained by evaporating the ether.

GAS-LIQUID CHROMATOGRAPHY:

A F and M model 720 duel column programmed temperature was used for gas chromatography in analysis of fatty acid methyl esters. The chromatography was equipped with a thermal detector. Hydrogen was used as a carrier gas (65 ml/min). The column used was 8' x 3/16" stainless steel, packed with 20% DEGS chromosorp (45-60 mesh). The detector and ingestion port were maintained at 300°C. The bridge current was 150 amps. The chart speed and attinuation were suitably maintained, so that measurable peaks could be obtained. Peaks were identified by comparison of their retention time with those of reference fatty acid methyl ester. Peak areas were obtained by triangulation and the fatty acid composition (weight %) was obtained from the area of percentages.

2. ESTIMATION OF IODINE NUMBER*

REAGENTS

IODINE SOLUTION: Dissolved 13.2 g of pure iodine in one litre of glacial acetic acid and when the solution

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* The chemistry and technology of edible oils and fats. Edited by Devine and P.N.Williams, Symposium Publications Division, Perganon Press (1961).

was cooled, 3 ml of bromine was added.

STANDARD SODIUM THIOSULPHATE SOLUTION - 0.1 N.

STARCH SOLUTION: Stirred 1 g of starch with 200 ml of water and boiled for 10 minutes and cooled.

POTASSIUM IODIDE SOLUTION: 150 g of potassium iodide was dissolved in water and diluted to 1 litre.

PROCEDURE:

Weighed 1 g of oil in an iodine flask, and 10 ml of chloroform and 30 ml of iodine solution were added with great care by means of a pipette. The flask was gently shaken by rotation and allowed to stand in a dark place with occasional shaking for 30 minutes. Next 10 ml of potassium iodide and 100 ml of freshly boiled water were added and titrated slowly with standard 0.1 N thiosulphate solution, depending on the indicator, first on the yellow color of the liquid and finally when that had nearly disappeared, on the blue color obtained by adding a few drops of starch solution. Blank determination was made in exactly the same manner, using only the reagents.

Iodine number was calculated using the formula 12.69 N (x-v)w, where w, was the weight of sample in g; v, the volume in ml of the thiosulphate solution used in the blank determination; N, the normality of thiosulphate solution.

3. DETERMINATION OF REFRACTIVE INDEX*

The refractive index was determined using a butyro refractometer. The temperature of the refractometer was controlled to within ± 1°C. The temperature as adjusted to 40° ± 1°C. It was ensured that the prisms were completely clean and dry. A few drops of the oil sample was placed on the lower sample. The prisms were closed by tightening firmly with the screw-head, and allowed to stand for one or two minutes. The instrument was adjusted to obtain the most distinct reading possible, thus the refractive index was determined.

4.ESTIMATION OF PEROXIDE NUMBER**

Dissolved 5 g of oil in 50 ml of (6+4) acetic acid - chloroform mixture, 1 ml of saturated potassium iodide was added and stirred by rotating the solution. After one minute, 100 ml of water was added and the liberated iodine was titrated with standard 0.01 N sodium thiosulphate solution, using 1% starch as indicator. A blank determination was simultaneously carried out.

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* Indian standard methods of sampling and test for oils and fats (Revised). ISI, Indian Standard Institution. 1964.

**Analysis of food. Winton - Andrew L Winton and Kate Barber Winton (1958) P.528-John Wiley & Sons Inc.; Chapman & Hall Ltd., London.

The peroxide value was calculated using the formula - 1000 (v-x) N/w, where w, was the weight of the sample in g; v, the volume in ml of sodium thiosulphate solution used in the test; x, volume of the sodium thiosulphate solution used in the blank and N, the normality of sodium thiosulphate solution.

5. ESTIMATION OF ACID NUMBER*

10 g of oil was weighed into a 500 ml Erlenmeyer flask to which 50 ml of neutral ethanol was added and the mixture was kept in a water bath at 60°C. When the contents of the flasks reached the bath temperature, 10 drops of 0.5% phenolphthalene was added. Later, the heated mixture was rapidly titrated with 0.1 N sodium hydroxide till the pink color persisted for 15 seconds.

The acid number was calculated using the formula $\frac{56.1\ Nv}{w}$, where w was the weight in grams of the sample, v the volume of sodium hydroxide solution used and N, the normality of the sodium hydroxide solution.

FAT ESTIMATION

Fat was estimated in products fried in sunflower oil and groundnut oil. The food samples used for fat

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* Analysis of food - Andrew L Winton and Kate Barber Winton, 1958, 3rd Edn. pg . John Wiley and Sons Inc., Chapman & Hall Ltd., London.

fat estimation were - boondi, poorie, potato chips and murku. These products were standardized before estimating their fat content. The standardized recipes are shown in Appendix - Table 1-4; pages i-iv. Since the frying temperature, surface area, composition of food and composition and type of oil used affect the fat absorption. All these conditions except the last were controlled, sunflower oil and groundnut oil were used. Fat absorption of foods was determined by the standard Soxhlet procedure.*

STORAGE PROPERTIES

THE SCHAAL TEST**:

The Schaal test was selected to determine the accelerated oxidation of oils. 100 ml of the oil sample was incubated in an open beaker at an elevated temperature of 60°C. The keeping quality was expressed in terms of the number of days required to produce organoleptic rancidity. Organoleptic rancidity is at a specific peroxide value of 75 meq of peroxide/kg of dalda and 100-125 for vegetable oils.

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*Practical Physiological Chemistry. Philip, B.Hawk, Bernard. L.Oser and William. H.Summerson. 13th Editon. McGraw - Hill, Book Company Inc. New York (1954) pg. 238.

**The Chemistry and Technology of food and food products. Morris.B.Jacobs. II Vol., page 1147.

A study of the storage behaviour of sunflower oil and groundnut oil was carried out for a period of three months. Oil samples were stored in three types of containers - namely glass bottles, ordinary Amul tins and white opaque plastic screw jars. The containers were thoroughly cleaned and dried before they were filled with the oil samples.

Oil samples stored were: 1. fresh oil, 2. oils in which potato chips were fried for half an hour, 3. one hour and 4. one and a half hours.

The method of preparation of potato chips was standardized. Standardized recipe is given in Appendix - table 3, page iii. In a single batch, fifteen potato slices of 0.15-0.2 cm thickness were fried at 180°C for two minutes. The potato chips were fried continuously for one and a half hours. Every half hour a certain amount of oil sample was removed and cooled. 100 ml of the heated oil was poured into the different containers. Throughout the experimental period all the samples were stored in a wooden cupboard at room temperature which ranged between 36 $\pm$ 2°C. The degree of deterioration of oils was determined by means of peroxide value and acid number.

HYDROGENATION OF SUNFLOWER OIL:

Hydrogenation is a process by which an oil in a liquid state is converted by action of gaseous

hydrogen in the presence of a solid catalyst into solid fat. These hard fats find use either in making soap or in edible products in which the degree of plasticity can be controlled to a considerable extent either during the hydrogenation step or during subsequent blending.

HYDROGENATION APPEARATUS*:

Hydrogenation unit consisted of a stainless steel vessel of one litre capacity provided with a sampling device, a stirrer and a thermocouple arrangement for measuring temperature. A pressure gauge to measure the hydrogen pressure upto 50 atmospheres was provided. Lowering of temperature when necessary was done by making use of stainless steel water cooling coil.

EXPERIMENTAL PROCEDURE:

700 gm of sunflower oil was charged into the autoclave along with 0.1% Nicket catalyst (Rufert Nicket which contains 25% of Nicket metal and 75% hardened fat). Electrolytic hydrogen (99.1% pure) was employed for hydrogenation. After the contents were charged the autoclave was sealed and the air in it was replaced by hydrogen.

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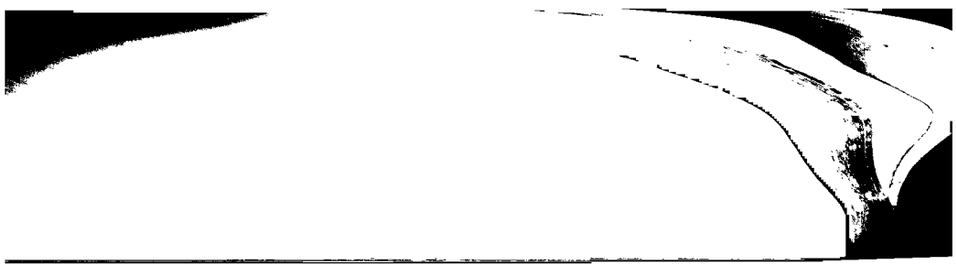
* Method obtained from Fats and Oils Unit, Regional Research Laboratories, Hyderabad.



Stirring was started and at the same time heating was also commenced. When the contents reached the required temperature of 180°C, hydrogen was let in and allowed to build upto the required pressure of 30 kg/sq.cm. The reaction was considered to have commenced when the hydrogen was let in for the first time, as the hydrogen was absorbed during the reaction. Fresh hydrogen was let in to keep the pressure constant. Samples were withdrawn at frequent intervals and tested for their melting point. When the melting point of the product reached about 27°C, (which is the body temperature) the reaction was stopped. The autoclave was allowed to cool down and the inside pressure was released before removing the cover. The time taken to get the product of the required melting point was approximately three hours.

As the product contained a bluish tinge, it was mixed with bleaching earth while hot, stirred well and filtered. By this process the catalyst and the bleaching earth were removed and a clear hydrogenated oil was obtained.

SENSORY EVALUATION

Organoleptic evaluation methods for foods are devised based on the type of foods and the objective

behind evaluation. To provide information regarding the acceptability of sunflower oil as a cooking medium, an organoleptic test was conducted. Groundnut oil was used for comparison as it was the oil used by most of the panel members. Sensory evaluation of foods broadly includes - selection and training of judges, standardization of the foods to be evaluated and actual testing of foods.

SELECTION AND TRAINING OF JUDGES:

Eight members of the staff and students of Foods and Nutrition Department were chosen for the sensory evaluation. The members chosen were all between the age groups of 21-35 years, healthy, willing to undergo training and evaluate the food products, and were readily available throughout the experimental period. A preliminary test for the selection of judges included the sensitivity threshold test, recognition threshold test and duo-trio test. The first two tests were conducted to assess the perception of the members and the latter to judge their capacity to differentiate between two products.

Sensitivity threshold is the stage or concentration where an individual is able to feel the taste of a substance. Recognition threshold is the stage or concentration where an individual is able to feel and

recognize the actual taste of a substance. Sensitivity and recognition thresholds for the basic tastes namely sweet, salt, sour and bitter of all the members were determined. In order to determine the judges sensitivity for the four basic tastes sugar, salt, citric acid and magnesium sulphate were made at 0.0001%, 0.001%, 0.01%, 0.1%, 0.25% and 0.5% concentrations. All the members were given a proforma and asked to check their sensitivity and recognition thresholds. Proforma for these tests is shown in Appendix - Table 5 page-v. These tests were repeated the next day and members with the following sensitivity and recognition thresholds were selected for the panel:

TABLE 4: SENSITIVITY AND RECOGNITION THRESHOLD LEVELS OF PANEL MEMBERS

Taste	Sensitivity threshold	Recognition threshold
Sweet	0.001%	0.01%
Salt	0.01%	0.1%
Sour	0.01%	0.1%
Bitter	0.001%	0.01%

Because the final products would be evaluated by paired comparison tests for the selection and training of judges, duo-trio test and triangle tests were used.

Furthermore since the most important aspect in the sensory evaluation was centred around acceptability of the oil used in the food preparations, even at the initial stages of selectionand training of judges food preparations, where the nature of oil would affect its quality characteristics were used. Thus in the duo-trio test, biscuits made from butter and dalda were used as test samples and boondi prepared from groundnut oil and safflower oil in case of triangle tests.

For the duo-trio test a coded biscuit sample was presented followed by two other coded biscuit samples, one of which was similar to the first sample. A proforma for the duo-trio test was given to all the members as shown in Appendix page-vi. The members were asked to check which of the two samples was similar to the first. All the members were able to identify the samples correctly. Next, the triangle test was conducted as a final test for selection.

In the triangle test, boondi prepared from groundnut oil and safflower oil was used. Proforma used for triangle test is shown in Appendix page-vii. Two identical and one different sample was presented simultaneously and the members were asked to identify the odd

sample. All the members were correct in their identification of the odd sample. Therefore all the members were included in the panel of judges for the sensory evaluation of sunflower oil products.

Training of the judges was done intensively for a period of fifteen days, during which time they gained sufficient experience in differentiating between two food products and assigning suitable scores to them. As the judges would be using the hedonic scale for the final evaluation, the method of use of the hedonic scale the various descriptive terms and scores assigned to the quality characteristics was discussed among the panel members. Hedonic scale was employed as it consists of a five point balance scale where the judge could easily and correctly, express a degree of liking by checking a point on the scale, which ranged from extreme approval to extreme disapproval. The score cards used in the evaluation are given in Appendix Table 14-23, pages xvi-xxv. Poories prepared from groundnut oil and gingely oil were used in the training of judges for the use of hedonic scale. All this training helped the judges to correctly assess the quality of the food samples and to obtain reasonable consistency in evaluation by the individual panelists as well as between panelists.

STANDARDIZATION OF FOOD PRODUCTS:

Standardization is a process by which the various ingredients, their weight, the equipment used, the temperature of cooking and time of cooking in a recipe are standardized. In a standardized recipe the yield, and size of the products are also standardized. Standardization is important in sensory evaluation as it eliminates variations in the food products due to different ingredients used, time of preparation, temperature of preparation, etc. Thus in the sensory evaluation of sunflower oil products, all the above mentioned factors were controlled by use of standardized recipes and the variable factor was only oil. For the preparation of control food samples groundnut oil was used and in the test sample - sunflower oil was used.

Generally fats and oils are used for deep fat frying, shallow frying, seasoning, baking and salad dressings. Therefore two food preparations in each method were standardized. The food products standardized are shown in Table 4 and the 6 standardized recipes are given in Appendix, Table 1,2,6-13, page-i, ii and viii-xv.

contd.....

TABLE 4: LIST OF FOOD PRODUCTS STANDARDIZED

Method	Preparation
1. Deep fat frying	Poories, boondi
2. Shallow frying	Chappati, dosa
3. Seasoning	Mixed vegetable curry, sambar.
4. Salad dressing	Mayonnaise, Vinegrette
5. Baking	Cakes, biscuits

The above products were standardized because they enjoy wide popularity and are included in the daily menus of many Indian families.

METHOD OF EVALUATION:

As environment may distract or influence the evaluation of judges, therefore, care was taken to conduct the sensory evaluation in an undisturbed room of comfortable temperature. The sample size, temperature of products, size and type of utensils used and coding were kept uniform. Stainless steel plates, tumblers and spoons of the same shape and size were used for the experiment. Drinking water was provided to panelmembers to remove any lingering taste of the previous food sample after each sample. Arrangements were so made that no judge had the opportunity

to watch another judge at the time of scoring. Evaluation was always conducted at 3 p.m. on all days when the judges were neither too hungry nor too full.

The evaluation of sunflower oil products was done in comparison with groundnut oil products, as groundnut oil is an accepted cooking oil and all the judges were using the groundnut oil at home. For the preparation of baked products, sunflower oil was hydrogenated and used (Method page 28). The test sample as well as the control samples were coded and presented to the judges for evaluation, so that the judges were not aware of the oil used in the control and test sample.

Two types of scoring were used in the evaluation - descriptive scoring and successive rating scale. In descriptive scoring, descriptive terms were given to the various quality characteristics - appearance, color, flavor, texture and taste of foods. After the judges finished scoring, these descriptive terms were converted to numerical scores, totalling to 100 points. A proportion of the total score was assigned to each of the constituent quality factor. Maximum marks were allotted to that quality characteristics which greatly influenced the overall product. The judges after

sampling the food, simply had to check on the score card, the descriptive terms which they felt aptly described the quality characteristics of the food products.

With a view of minimizing bias and subjective errors, another scoring method known as successive rating scale based on the principle of hedonic scale was employed. After an interval of 15 minutes, after the evaluation of the food samples by descriptive scoring, the judges were asked to evaluate the same products using a successive rating scale. Scorecard for successive rating scale is given in Appendix - table 24, page xxvi.

The scores allotted to each quality characteristics for each food product by all the judges was statistically analysed by employing analysis of variance.

CONSUMER ACCEPTABILITY

To elicit information regarding the consumer acceptance of sunflower oil as a cooking medium, a survey was conducted using a questionnaire method. The questionnaire is given in the Appendix page 26-30.

Since there was a limited supply of sunflower oil, the consumer population consisted of only eighty families.

Thus a careful selection of the consumers had to be made. The women being the chief decision makers of foods and purchasers in a family, they were interviewed. Females who were literate and were willing to give the necessary information carefully were included in the survey. A careful selection was made to include consumers from all income groups ranging from Rs. 250 to 2,000, all categories of employees such as house-wives, attenders, clerks, teachers, and administrators and belong to all castes. Though only 80 families were interviewed, each family consisted of five members on an average. But it was the home-makers' opinion which was recorded. Some of the quesionnaires were distributed among the office staff, teaching staff and students of Home Science College, since they represent a homogenous group. Rest of the consumers were selected randomly from Gagan Mahal Colony and Panjagutta Colony, as these colonies consisted of people from various sections of the community. Each consumer was given 300 ml sample of sunflower oil along with a questionnaire. All the consumers were approached individually and were carefully instructed regarding the filling up of the questionnaire. The consumers were asked to prepare four products - poories, papads, chappaties and beans curry using sunflower oil. The

The consumers were requested to fill up the questionnaire by comparing the sunflower oil with the oil they use at home. The food products were specified as there would be uniformity in the preparations among the consumers. The consumers were asked the type and quantity of oils they purchase and the reasons for purchase of that particular oil. The consumers' opinion regarding the quality characteristics and cooking characteristics of sunflower oil was procured. Information regarding the consumer acceptance of sunflower oil and their willingness to change over to the same was obtained. Furthermore, information regarding the cost level at which the consumers were willing to buy sunflower oil was also elicited.

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

FATTY ACID COMPOSITION:

The sunflower oil samples obtained from Hyderabad and Canada were analysed for the fatty acid composition by Gas-Liquid Chromatography. The results of the fatty acid composition are given in Table 6, page 43. Figures 1-4, Appendix page xLv-xLviii, indicate the fatty acid composition of the groundnut oil and sunflower oil of Hyderabad and Canada and Hydrogenated sunflower oil.

Though the botanical variety of Hyderabad and Canadian samples of sunflower oil ("Armaveric") used in the study were the same, a wide variation in the composition of the fatty acids was observed between the two. The variation was higher in unsaturated fatty acids (35%) than in the saturated acids (1-2.5%). Linoleic acid was found to be higher in the Canadian variety (74.83%) as against 40.9% in the Hyderabad variety. The linoleic acid fraction in Canadian sample was higher by 33.93% than its Hyderabad counterpart. But the oleic acid fraction was higher in Hyderabad variety (50.7%) rather than in Canadian variety (15.3%) the difference being 35.4%. The difference in the saturated acids palmitic and stearic was negligible.

The percentage of total unsaturated acids in both sunflower oil samples were the same, but there was a marked difference in the individual unsaturated fatty acids, the variation being mainly in the oleic and linoleic acid fractions. When the linoleic fraction was high, the oleic acid fraction was low and vice-versa. Since the botanical variety of both samples were the same, the difference observed in the fatty acid composition can only be attributed to be cultivation of sunflower crop in different climatic conditions. To a certain extent, the low linoleic acid level of sunflower oil from Hyderabad may be attributed to its being a kharif rather than a rabi crop.

Sunflower grown in cooler climates as those of the temperate regions, due to slow ripening of seeds, may yield oil with a higher level of unsaturation. But in warmer tropical regions such as India, where the seed ripening is rapid, may result in a lower level of unsaturation. Variation in the fatty acid composition noticed in the present study is in accordance with the findings of Barker, C., and Hilditch, T.P. (1950).

Comparing the fatty acid composition of sunflower oil of Canadian source, with the composition of sunflower oil reported by Eric.D.Putt (1966) (as indicated in Table-6) for the same botanical variety, no significant differences

TABLE 6: PERCENTAGE FATTY ACID COMPOSITION OF SUNFLOWER OIL SAMPLES, SAFFLOWER OIL AND GROUNDNUT OIL

Fatty acids	Sunflower oil(Hyderabad)	Sunflower oil (Canada)	Sunflower oil*	Sunflower oil(hydrogenated)	Safflower oil**	Groundnut oil	Dalda*
Palmitic acid	5.70	8.20	5.98	0.70	7.00	14.81	14.10
Stearic acid	2.70	1.17	4.31	2.20	4.40	0.65	12.70
Oleic acid	50.70	15.30	18.09	87.15	12.80	51.86	65.20
Linoleic acid	40.90	74.83	71.56	9.90	75.80	31.71	4.10
Arachidic acid	-	-	-	-	-	0.69	1.60
Behenic acid	-	-	-	-	-	0.19	2.30

* Fatty acid composition of sunflower oil from different varieties and locations. Eric D.Putt. Proceedings of the Second International Sunflower Conference (1966). Published by Research Branch, Canada Department of Agriculture.

** Nutritive value of used oils and Dalda: Their effect on Cholesterol level of albino rats - G.Vimala Devi (1971) Dissertation.

were observed between the two in fatty acid composition. Eric D.Putt (1966) also pointed out that it is the climate rather than the botanical variety, which largely influences the level of unsaturation of sunflower oil.

Groundnut oil is most popularly consumed by the Indian population. Therefore the fatty acid composition of sunflower oil was studied in relation to groundnut oil. A comparison of the composition of these two oil samples reveal a slightly higher level of unsaturation in sunflower oil (91.6%) as against groundnut oil (83.63%). Though no difference was observed in oleic acid level the linoleic acid level of groundnut oil was nearly 10% lower than sunflower oil. The groundnut oil had nearly double the saturated acid fractions - 16.34% as against 8.4% in sunflower oil.

Many investigators have reported that the fatty acid composition of sunflower oil closely resembles that of safflower oil. The fatty acid composition of sunflower oil from Canada and not Hyderabad, was comparable to that of safflower oil. Nevertheless, a slightly higher level of total unsaturated acids was found in both sunflower oil samples, but the linoleic acid percentage was higher in safflower oil. Unlike sunflower oil, the fatty acid composition of safflower does not vary with the climate.

Hydrogenation refers to the process whereby liquid fats are changed to solid fats by introducing hydrogen into some, but not all, of the double bonds of the carbon chains. Carotenoids which give the characteristics organge-red color to the oils are highly unsaturated. Therefore when oils are hydrogenated, hydrogenation of the pigments also occurs, with a reduction in color. Commercially, hydrogenation is an important process, where the liquid fats are converted into natural plastic fats which are extensively used in baked foods. Hydrogenation also improves the keeping quality of oil, due to the saturation of the double bonds.

Hydrogenation of sunflower oil of Hyderabad variety resulted in a decrease in the level of unsaturation. But the fall in the unsaturation of the hydrogenated oil was mainly due to the increase in the oleic acid percentage by 34.45% with a decrease in linoleic acid percentage by 31.9%. The fall in the linoleic acid percentage is accompanied by an increase in the oleic acid percentage because of the conversion of linoleic acid to oleic. According to Meyer, L.H., (1961) in most oils with a high content of unsaturated acids the possible reactions are conversion of linolenic to linoleic or isolenoleic, linoleic to oleic and oleic to stearic. In the presšent study not much of oleic acid was converted to

stearic acid, though a large percentage of linoleic acid was converted to oleic acid.

On hydrogenation of groundnut oil (as observed by the analysis of the fatty acid composition of dalda) it was found that there is a considerable increase in the oleic and stearic acid percentage. Comparing the fatty acid composition of dalda with hydrogenated sunflower oil, it was observed that the percentage of saturated acids was higher in dalda (19.30%) while the level of unsaturation was higher in hydrogenated sunflower oil (27.75%). These observations indicate the suitability of using sunflower oil in the hydrogenation of oils.

Unlike fats, which are concentrated sources of energy, vegetable oils in addition contribute essential fatty acids to the diet. Comparing the linoleic acid of all the three vegetable oils both sunflower of Canadian variety and safflower oil had a linoleic acid fraction of 75%, followed by sunflower oil of Hyderabad variety (40.9%) and least linoleic acid level was observed in groundnut oil being 31.72%. Linoleic acid is known to reduce the cholesterol level of the blood and thereby preventing atherasclerasis to a certain extent. The nutritive value of any oil cannot be judged merely by its energy contribution but also by its essential fatty acid content especially linoleic acid fraction. Judging the nutritive value of oils produced in Hyderabad by the

linoleic acid levels, safflower oil is of most superior quality, followed by sunflower oil, while that of groundnut oil was comparatively inferior. Though the linoleic acid fraction of sunflower oil grown in Hyderabad was adversely affected due to the warm Hyderabad climate, it was still found to be superior to groundnut oil produced in the same place.

IODINE VALUE:

The iodine value of sunflower oil from Canada and Hyderabad was 126.0 and 119.5 respectively. The iodine value of groundnut oil was only 89.0. As iodine value is a measure of the degree of unsaturation, the results indicate that the sunflower oil from Canada is higher unsaturated followed by the Hyderabad variety and groundnut oil. The iodine value for sunflower oil from Hyderabad (119.5) does not conform with the ISI specifications of 125-140 for sunflower oil. This is probably due to the low linoleic acid percentage. But the iodine values observed was within the iodine value range of 113-142.9 reported by Eckey, E.W. (1959).

REFRACTIVE INDEX:

The refractive index was found to be the highest for Canadian sunflower oil 1.4685, followed by Hyderabad

variety 1.4656, the least refractive index being observed in groundnut oil 1.4640. The sunflower oil from Canada had the highest refractive index which corresponds to its high iodine value and linoleic acid fraction, whereas lowest refractive index was observed for groundnut oil which corresponds to its least iodine number and linoleic acid percentage. While all the values for sunflower oil from Hyderabad fell between the two oils. Refractive index of both varieties of sunflower oil correspond with the ISI specification ranging from 1.4650-1.470. Because the difference in the refractive index of all the three oil samples was negligible, this method alone is not sufficient to identify the oil or study the level of unsaturation of oils.

TABLE 7: CHEMICAL CHARACTERISTICS OF SUNFLOWER OIL AND GROUNDNUT OIL

Oil sample	Iodine value	Refractive index
Sunflower oil (Hyderabad)	119.5	1.4656
Sunflower oil (ISI)* ..	125-140	1.465-1.470
Sunflower oil (Canada) ..	126.0	1.4685
Groundnut oil ..	89.0	1.4640

* Indian Standard specification for solvent extracted sunflower oil, refined. UDC 665. 347.8. 1967. Indian Standards Institution, New Delhi.

FAT ABSORPTION

Deep fat frying is a popular method of cooking a wide variety of foods for any meal or for snacks. Fats and oils contribute to the appetite appeal and satiety value of the diet. Absorption of fat by foods is necessary to know the fat content of the diet. Any fat or oil that is absorbed to higher per cent by foods, is unpleasant to taste and undesirable as this may lead to obesity, hypercholestremia, diabetes and hypertension.

Poorie, boondi, murku and potato chips were the deep fried foods tested for fat absorption. The results are tabulated in Table 8.

TABLE 8: ABSORPTION OF FAT BY DEEP FRIED PRODUCTS

Food sample	% fat absorption of sunflower oil products (gms)	% fat absorption of groundnut oil products (gms)	% fat absorption of groundnut oil products (gms)*
Poorie ..	10.0	8.75	11.5
Murku ..	20.0	15.00	28.3
Boondi ..	25.0	20.00	48.5
Potato chips	35.3	30.20	14.6

Among all the food products, potato chips absorbed more oil, followed by boondi, murku and poorie in the

* Masoda Begum (1970). Study on factors influencing fat absorption in deep fried foods. Dissertation.

decreasing order of absorption. Samples fried in sunflower oil absorbed a higher proportion of fat compared to the groundnut oil samples. Except in the case of poories the absorption of fat by the sunflower oil products was greater by 5%.

The extent of fat absorption recorded in the present study are in line with the results reported by Masoda(1970) for the same products fried in groundnut oil as indicated in Table 7. The fat content of deep fried products of sunflower oil and groundnut oil ranged from 8.75-35.3%. This value is in accordance with the values stated by Heild and Joslyan (1965) who reported that the amount of fat absorbed in deep fried foods varies from 10 to 40%.

CHANGES IN THE CHEMICAL CONSTANTS OF SUNFLOWER OIL ON HEATING

Much of the fats and oils consumed by human beings, particularly in India, are heated, and the conditions of heating vary widely. The temperature of frying usually ranges from 160°C-200°C. In the process of cooking, oils are heated in open pans for a long time, from half an hour to two hours, the residual oil after the day's operation is supplemented with fresh oil and reheated again. This procedure accelerates oxidative and other changes, the changes being more marked in unsaturated oils than in saturated oils. Linoleic acid is the predominant polyunsaturated

fatty acid in most of the oils used for frying. Since the polyunsaturated fats are more susceptible to degradation, the present investigation was designed to study the changes in the unsaturated fatty acid content dn heating.

The large differences in the fatty acid composition of vegetable oils after use in deep fat frying prompted a study of the effect of heating on the fatty acid composition and chemical characteristics of sunflower oil. The changes in the chemical constants of sunflower oil and groundnut oil on frying potato chips at 180°C for half an hour, one hour and one and a half hours has been represented in Table 9. Figures 5-10 Appendix page xLix-Liii, give the fatty acid composition of heated sunflower and groundnut oil samples.

In the present study the major changes occurring in the heated oils is the lowering of linoleic acid percentage and elevation of oleic acid percentage. These changes were more marked in groundnut oil as against sunflower oil. Secondly, it was observed that the longer the period of heating, greater was destruction of linoleic acid. The destruction of linoleic acid after heating for half hour, one hour and one and a half hours was 5.17, 5.27 and 17.93 respectively for sunflower oil and 2.37, 10.21 and 20.72 respectively for groundnut oil. Though

in the first half hour linoleic fraction of groundnut oil suffered less losses, on subsequent heating, groundnut oil samples incurred greater loss of linoleic acid.

The second important feature noticed on heating oils was the increase in the oleic acid fraction. The increase in the oleic acid percentage of oil samples heated for half an hour, one hour and one and a half hours was 8.72, 6.57 and 7.73 respectively for sunflower oil and 3.75, 9.53 and 11.51 for corresponding groundnut oil samples.

The results obtained in the present investigation are similar to the finding of Alan. I.Fleischenan, et al., (1963). On heating they found a decrease in linoleic acid fraction by 4% and increase in the oleic acid by 3.69% for groundnut, and in case of safflower oil, the destruction in linoleic acid was 13.4% and increase in oleic acid was 7.96%. They further, reported that the higher the unsaturation of oils, the greater is the destruction. But in the present study, inspite of sunflower oil being more unsaturated the percentage destruction of unsaturated fatty acid was less compared to groundnut oil. This can be possibly be due to the presence of higher levels of vitamin-E in sunflower oil which has a stabilizing effect on the linoleic acid fraction.

TABLE 9: CHANGES IN THE COMPOSITION AND REFRACTIVE INDEX OF SUNFLOWER OIL AND GROUND-NUT OIL DUE TO HEATING

% fatty acid composition and chemical characteristics	Raw sunflower oil(Hyderabad)	Sunflower oil heated for ½ hour	Sunflower oil heated for one hour	Sunflower oil heated for 1½ hour	Raw groundnut oil	Groundnut oil heated for ½ hour	Groundnut oil heated for one hour	Groundnut oil heated for 1½ hour
Palmitic acid	5.70	3.54	5.18	6.87	14.81	19.89	18.82	27.65
Stearic acid	2.70	1.29	1.58	1.70	0.65	0.31	0.79	0.27
Oleic acid	50.70	59.42	57.27	68.45	51.86	48.11	57.64	59.62
Linoleic acid	40.90	35.73	35.63	22.47	31.77	29.40	21.56	11.05
Arachidic acid	-	-	-	-	0.69	0.99	1.17	1.37
Euric acid	-	-	-	-	0.19	0.55	-	-
Refractive Index	1.4656	1.4659	1.4661	1.4663	1.4640	1.4647	1.4647	1.4650
Saponification number	-	-	-	-	-	-	-	-

Thus excessive heating of oils results in the decrease in the polyunsaturated fatty acids, thus altering the saturated and unsaturated fatty acid ratio. In the heat treatments applied to both oils, the increase in oleic acid was nearly parallel to decrease in the linoleic acid percentage. As natural fats vary to a great extent in the occurrence of antioxidants, it is therefore not surprising when contradictory results are obtained.

REFRACTIVE INDEX OF HEATED OILS:

The refractive indices of raw and heated sunflower oil and groundnut oil samples are tabulated in Table 9. For every half hour of heating the refractive index of both oils increased by 0.003 which is negligible. The difference in the refractive index in the heated oil samples is due to the differences in the viscosity of oils.

CHANGES ON STORAGE OF SUNFLOWER OIL

The universal acceptance of deep fried foods has markedly increased the consumption of fats and oils. Oils and fats gradually deteriorate on storage and more so on heating, and become unfit for human consumption. Heating results in development of color, objectional flavor and loss of resistance to rancidity due to development of peroxides and hydrolysis of the triglycerides.

In the present study, peroxide value and acid number were used to assess the storage properties of sunflower oil.

ACCELERATED RANCIDITY TEST:

Table 10 gives the peroxide value of oils as determined by the accelerated rancidity tests. A graph plotted to indicate the rise in peroxide value is represented in figure 11 on page 56.

TABLE 10: PEROXIDE VALUE OF OILS AS DETERMINED BY THE SCHAAL TEST

Days	meq peroxide per kg oil		
	Groundnut oil	Sunflower oil (Hyderabad)	Sunflower oil (Canada)
0 days	0	0	0
3rd day	25	30	18
5th day	35	44	32
7th day	40	55	50
9th day	55	69	75
10th day	62	80	80
12th day	70	98	100
13th day	85	102	105
14th day	100	106	110

Color changes were observed during the accelerated rancidity tests. In all the samples for the first five

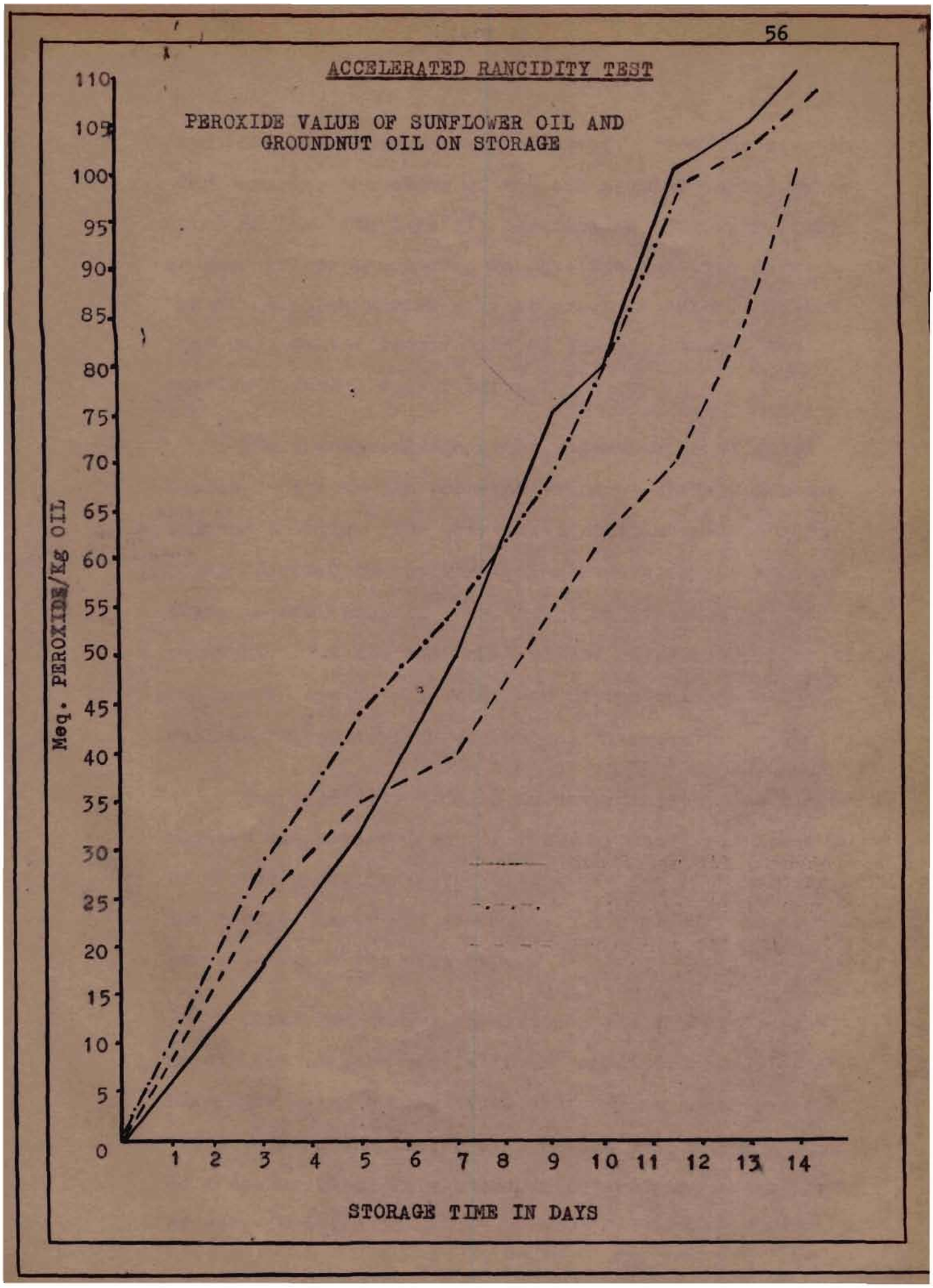
Figure 11

Key to figure 11

_____ Sunflower Oil (Canada)

-.-.-.-. Sunflower Oil (Hyderabad)

- - - - - Groundnut Oil


ACCELERATED RANCIDITY TEST
PEROXIDE VALUE OF SUNFLOWER OIL AND GROUNDNUT OIL ON STORAGE
Meq. PEROXIDE/Kg OIL
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
1 2 3 4 5 6 7 8 9 10 11 12 13 14
STORAGE TIME IN DAYS

days, no color changes were observed. From the seventh day onwards, the color of the oil samples turned paler, until on the 11th day, all the samples were very light or pale yellow in color. On the 12th and 13th days, again the oil samples turned a light brown in color. On the 14th day, at the termination of the experiment, the oil samples turned a deeper brown in color.

The characteristic color pigmentation of an oil sample is due to the presence of carotenoids which are soluble in oils. The decrease in the intensity of the color observed on the first eleven days of the storage test, is most probably due to the destruction of the color pigments. But the darkening of the color on further heating may be due to the oxidation of the tocopherols as well as polymerization of the triglycerides.

The rancidity of oils as determined by the flavor changes was observed on the 10th day which was found to be 80 meq peroxide/kg for both varieties of sunflower oil. The rancid flavor for groundnut oil was observed at 62 meq peroxide/kg on the same day.

Under the normal conditions, the flavor changes in oil samples are very slow and onset of organoleptic rancidity takes a long time. But during accelerated oxidation tests, the flavor changes are more rapid and markedly noticeable. This helps in determining the velocity of deterioration of oil samples.

At the commencement of the experiment no peroxide value was observed in all the three oil samples investigated. By the third day of the experiment, the peroxide value of sunflower oil of Hyderabad variety showed the highest value of 30 meq peroxide/kg oil, whereas the Canadian variety showed only 18 meq peroxide/kg oil. The groundnut oil sample had a peroxide value of 25 meq peroxide/kg oil. Even on 3rd and fifth day sunflower oil of Hyderabad variety had a higher value than the Canadian variety and groundnut oil. The peroxide value recorded for sunflower oil on 7th day (55 meq peroxide/kg oil) was noticed, only on 9th day in case of groundnut oil, showing that groundnut oil deteriorates less rapidly. The increase in the peroxide value of groundnut oil from fifth day to seventh day was by 5 meq peroxide/kg oil, but it was double in case of sunflower oil. By the tenth day it was observed that both samples of sunflower oil were at the same peroxide value of 80 meq peroxide/kg oil. On the 14th day, it was observed that sunflower oil of Canadian variety recorded the highest peroxide value of 110 meq peroxide/kg oil followed by the Hyderabad variety 106 meq peroxide/kg oil, the groundnut oil recording 100 meq peroxide/kg oil.

Accelerated rancidity follows a different course from normal oxidation and the composition of the oil has an important bearing on the relative velocities of the

reaction in the oil samples. If two samples of fat or oil exhibit considerable disparity in stability under accelerated conditions, it may be expected that a more or less similar disparity will be found under normal storage conditions. In the present study, the findings indicate that sunflower oil of Hyderabad is likely to develop rancidity sooner than either Canadian sunflower oil or groundnut oil till a period of time (10 days). Later on both sunflower oil samples have almost the same peroxide values (10th-13th day). The peroxide value of groundnut oil increased less rapdily than either of other two oils. It is therefore likely that sunflower oil becomes rancid earlier than groundnut oil.

*Organoleptic rancidity is at a specific peroxide value of 20 meq peroxide/kgfor hydrogenated oils and 100-125 meq peroxide for vegetable oils. Accordingly the rancid flavors observed in the present study on the 14th day is at peroxide level of 106, 110 and 100 confirming with standards fixed for food products. But the specific peroxide value for detectable rancidity being more or less similar by 14th day for all the three oils, earlier onset of rancidity for sunflower oil should not be considered as major determining factor in the purchase

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* The Chemistry and Technology of food and food products. Morris, B.Jacobs. II-Vol. page 1147.

of this oil. Thus sunflower oil can be an equally good substitute for groundnut oil or any other oil.

NORMAL RANCIDITY TEST:

An important phase of the chemistry of fats and oils is their spoilage or development of rancidity. Rancidity is a collective term applied to any 'off-flavors' in fats and oils. Fats do not become toxic upon spoiling as some other foods do, they become unacceptable to the palate. True rancidity in fats, however, is confined to the chemical breakdown of the fat molecule. This may occur in two ways. One is oxidative rancidity, in which the oxygen from the air attacks the fatty acid portion of the triglyceride and splits off the fragments rather than the whole fatty acid. This can be determined by the peroxide value. Second is the hydrolytic rancidity in which the fatty acids split from the glycerol molecule. This can be determined by the acid number. Both reactions can proceed simultaneously, and once the breakdown of fats has occurred, the rancidity proceeds at a rapid rate. Temperature, moisture, the amount of air in contact with fat, light, as well as the presence or absence of antioxidants and peroxidants influence the rate of rancidity. There are three stages in the rancidity of oils. First stage where the fats and oils become rancid slowly. This is called the induction period and it is

followed by a second period in which the uptake of oxygen is much rapid. Rapid deterioration often continues for an extended period of time after which the rate falls off. This is the third and final stage.

In the present study the deterioration of oils was determined by peroxide value and acid number, keeping two aspects in view, i.e.,

(a) Effect of heat treatments for different length of time (half an hour, one hour and one and a half hours) on the storage properties of sunflower oil;
(b) Effect of containers - glass, plastic and tin on the storage properties of oil.

PEROXIDE VALUE:

The peroxide value of a fat or oil is the amount of peroxides present expressed as milli-equivalents of peroxide-oxygen per kilogram of fat or oil.

Sunflower oil was found to turn rancid at a faster rate as compared to groundnut oil as indicated in Table 11. The deterioration of oil was higher in heated samples as against raw samples. Plastic was found to be a better container for storage of oils, followed by glass and tin, as determined by the peroxide value. Table 11 gives the

changes in peroxide value on heating and storage of sunflower oil and groundnut oil. (Appendix, Table 25 and 26, pagexxxi and xxxii)

TABLE 11: CHANGES IN THE PEROXIDE VALUE ON HEATING AND STORAGE OF SUNFLOWER OIL AND GROUNDNUT OIL

	milli-equivalents of peroxide/kilogram oil							
	Fresh oil		Heated for ½ hour		Heated for one hour		Heated for 1½ hour	
Days	Sunflower oil	Groundnut oil	Sunflower oil	Groundnut oil	Sunflower oil	Groundnut oil	Sunflower oil	Groundnut oil
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	0.48	0.18	0.54	0.23	0.57	0.31	0.59	0.35
50	0.79	0.33	0.89	0.39	0.91	0.42	0.96	0.46
60	1.10	0.52	1.12	0.66	1.21	0.84	1.23	0.92

A graph was plotted to indicate the rise in peroxide value in sunflower oil and groundnut oil which is given in figure 12 on page 63.

The results indicate that oils heated for 180°C for one and a half hours do not develop oxidative rancidity. It is only when the oils are heated and stored for a long period that oxidative rancidity occurs. Further, there was no marked difference in raw and heated oil samples even when on storage for 60 days. For both the oil samples it was observed that for the first 30 days, the

Figure 12

Key to figure 12

— — Sunflower oil heated for 1½ hr

. . . . Sunflower oil heated for 1 hr

— — — Sunflower oil heated for ½ hr

—.^.—.^. Fresh sunflower oil

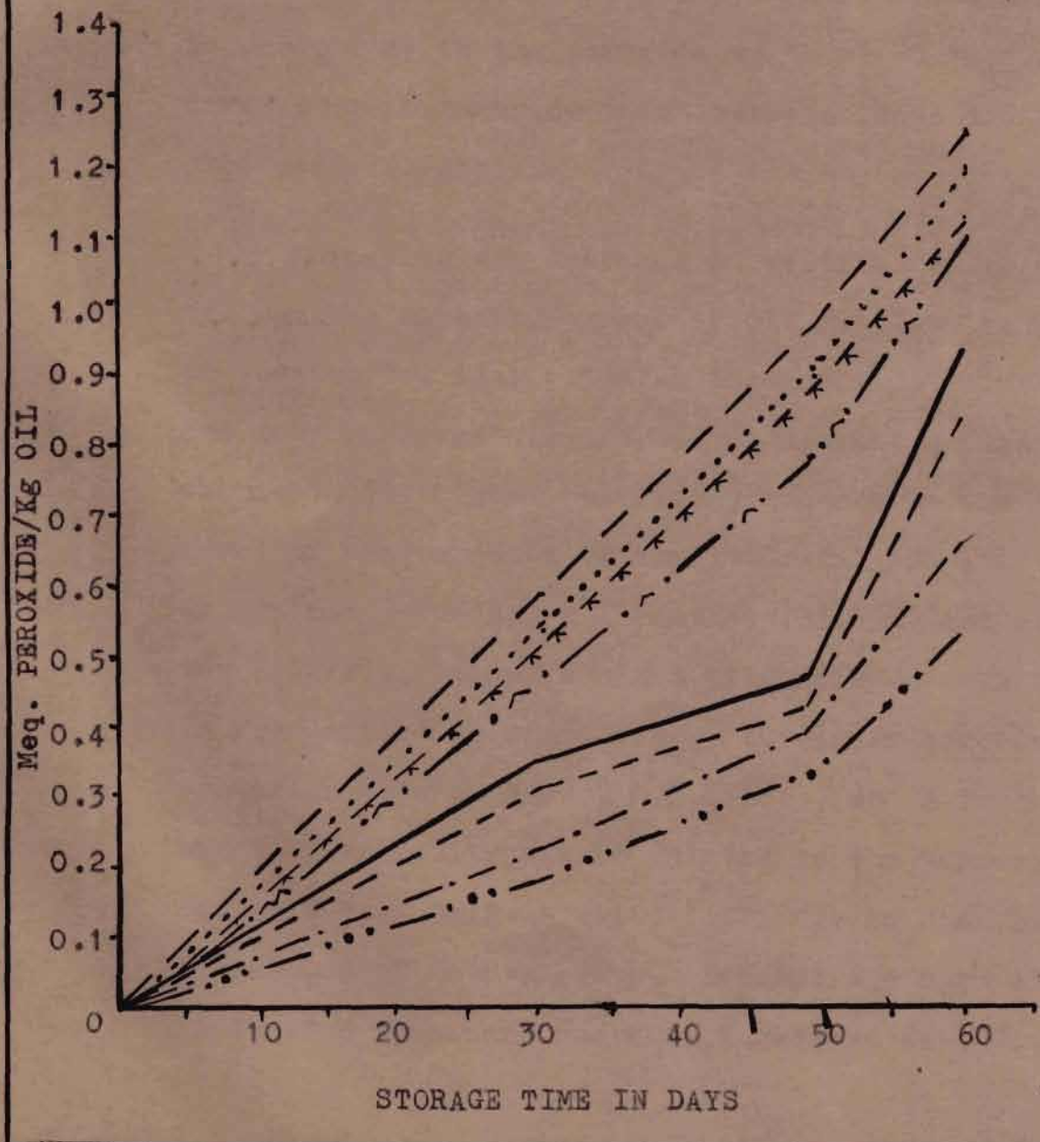
——— Groundnut oil heated for 1½ hr

- - - - Groundnut oil heated for 1 hr

.-.-.-. Groundnut oil heated for ½ hr

_..._... Fresh groundnut oil

CHANGES IN PEROXIDE VALUE ON HEATING AND STORAGE OF SUNFLOWER AND GROUNDNUT OILS



changes in the peroxide value was very slight, on further storage for 20 days, the increase in peroxide value was slightly higher, but not very marked. But in the last 10 days, the peroxide changes were very marked, the increase in peroxide value in this period was nearly double that recorded in the first 30 days. From this it can be seen that the increase in peroxide value occurs very slowly at first which is followed by a second period where the increase is slightly higher. Finally, there is sharp rise in the peroxide value at 60 days. The difference in peroxide value between fresh and heated samples was negligible.

Comparing the increase in peroxide value of sunflower oil samples with the groundnut oil samples, at all levels of treatments, nearly double the peroxide value was recorded for sunflower oil samples as against groundnut oil samples. The higher peroxide value may be due to the higher level of unsaturation of sunflower oil samples (91.2%) as against groundnut oil samples (83.63%) and also due to the higher vitamin-E content of sunflower oil which protects it from oxidative rancidity. This is in accordance to the statement made by Meyer, L.H.(1961), who said that the onset of rancidity may be related to the unsaturation of fat, although this is quite difficult to show by direct comparison of natural fats. Because the natural fats differ in their antioxidant content, Nageswara Rao, C., and

Narasinga Rao, B.S.(1968) also observed that increase in the peroxide value of various vegetable oils and fats was not related to the degree of unsaturation. They also attributed the differences to vitamin-E content of fats. Further, fats low in initial peroxide value seem to show a sharp increase while those with high initial peroxide value show little change in peroxide value on heating.

EFFECT OF CONTAINERS ON THE PEROXIDE VALUE OF STORED SUNFLOWER OIL:

The effect of containers on the peroxide value of stored sunflower oil and groundnut oil is tabulated in Table 12. A graph was plotted to indicate the effect of containers on the peroxide value of stored sunflower oil and groundnut oil which is given in figure 13 on page 66.

TABLE 12: EFFECT OF CONTAINERS ON THE PEROXIDE VALUE OF STORED SUNFLOWER OIL AND GROUNDNUT OIL

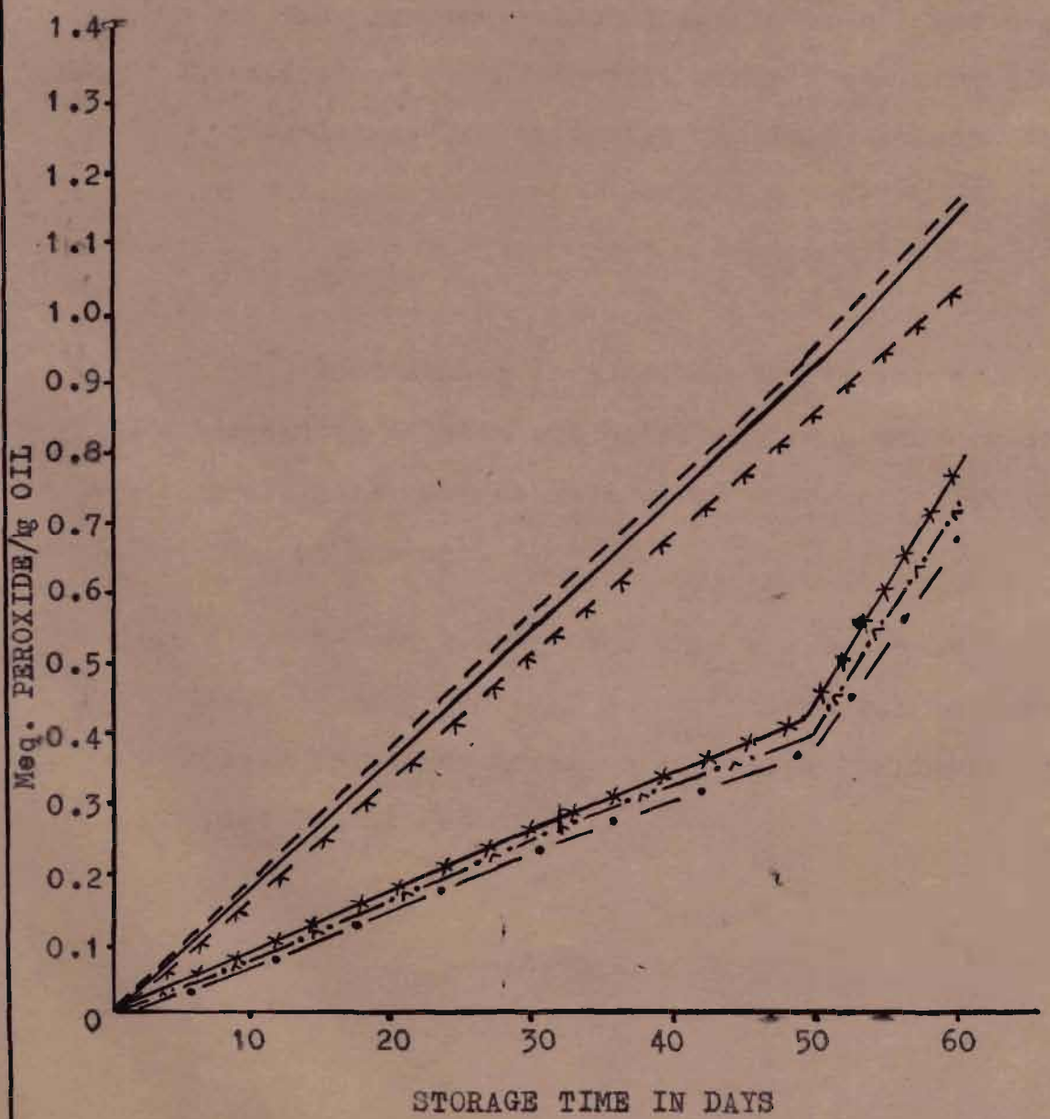
Days	Milliequivalents peroxide/kilogram oil					
	Glass		Plastic		Tin	
	Sunflower oil	Groundnut oil	Sunflower oil	Groundnut oil	Sunflower oil	Groundnut oil
0	0.0	0.0	0.0	0.0	0.0	0.0
30	0.52	0.25	0.54	0.27	0.57	0.28
50	0.90	0.40	0.84	0.38	0.92	0.42
60	1.19	0.74	1.06	0.70	1.20	0.78

Figure 13

Key to figure 13

- - - - Sunflower oil stored in tin containers
——— Sunflower oil stored in glass containers
⩚ ⩚ ⩚ Sunflower oil stored in plastic containers
X X X Groundnut oil stored in tin containers
-∘∧∘-∘∧∘ Groundnut oil stored in glass containers
•—•—∘ Groundnut oil stored in plastic containers

EFFECT OF CONTAINERS ON THE PEROXIDE VALUE OF SUNFLOWER OIL AND GROUNDNUT OIL



On storage of sunflower oil for 60 days the peroxide was 1.19, 1.06 and 1.20 for glass, plastic and tin containers and 0.74, 0.70 and 0.78 respectively in case of groundnut oil.

Though higher peroxide values were recorded for oil stored in tin, followed by glass and plastic the difference was negligible (0.02-0.04). These results were similar for both sunflower oil and groundnut oil samples. But the peroxide value of sunflower oil was nearly double compared to groundnut oil. Thus containers did not seem to influence the oxidative rancidity as much as the nature of oil.

ACID NUMBER:

Acid number is a method to determine the hydrolytic rancidity of fats and oils. It is a measure of the free fatty acids and as such gives information as to the condition of the oil.

The changes in the acid number on heating and storage of sunflower oil and groundnut oil is given in Table 13. (For details refer appendix table 27 and 28, page xxxiii and xxxiv).

contd.....

TABLE 13: EFFECT OF HEAT TREATMENT AND STORAGE ON THE ACID NUMBER OF SUNFLOWER OIL AND GROUNDNUT OIL

Days	Raw oil		Oil heated for ½ hour		1 hour		1½ hour	
	Sun-flower	Ground-nut	Sun-flower oil	Ground-nut oil	Sun-flower oil	Ground-nut oil	Sun-flower oil	Ground-nut oil
0	0.44	0.36	0.46	0.38	0.49	0.41	0.50	0.45
30	0.63	0.45	0.71	0.55	0.72	0.57	0.80	0.58
50	0.90	0.89	1.01	0.94	1.35	1.02	1.37	1.07
60	1.47	1.20	1.55	1.32	1.67	1.40	1.71	1.49

A graph was plotted to indicate the increase in acid number of heated and stored sunflower oil as shown in figure 14, page 69.

In all heat treated sunflower oil samples the difference in the acid number ranged between 0.01-0.34, while the increase in acid number on storage was 1.03-1.15. The difference in the acid number in all heat treated groundnut oil samples was 0.02-0.29, while the increase in acid number on storage was between 0.84-1.04.

A graph was plotted to indicate the increase in the acid heated and stored groundnut oil as indicated in figure 15, page 70. Comparing the increase in acid number on 60 days storage of raw and heated samples (½ hour,

Key to figure 14

- - - - Sunflower oil heated for 1½ hr

.-^-^. Sunflower oil heated for one hr

. . . . Sunflower oil heated for ½ hr

—.^.— Fresh sunflower oil

CHANGES IN ACID NUMBER ON HEATING AND STORAGE OF SUNFLOWER OIL

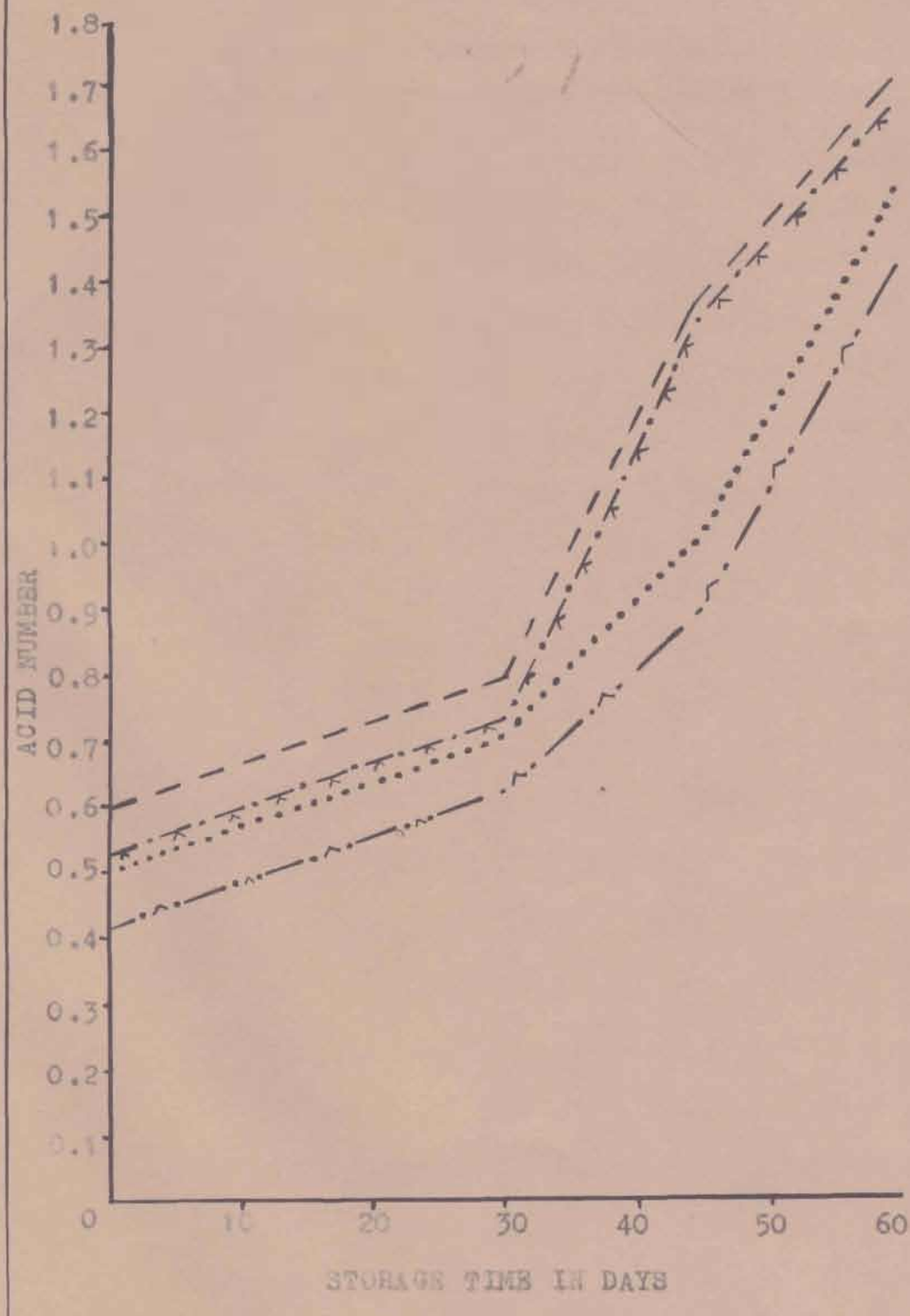


Figure 15

Key to figure 15

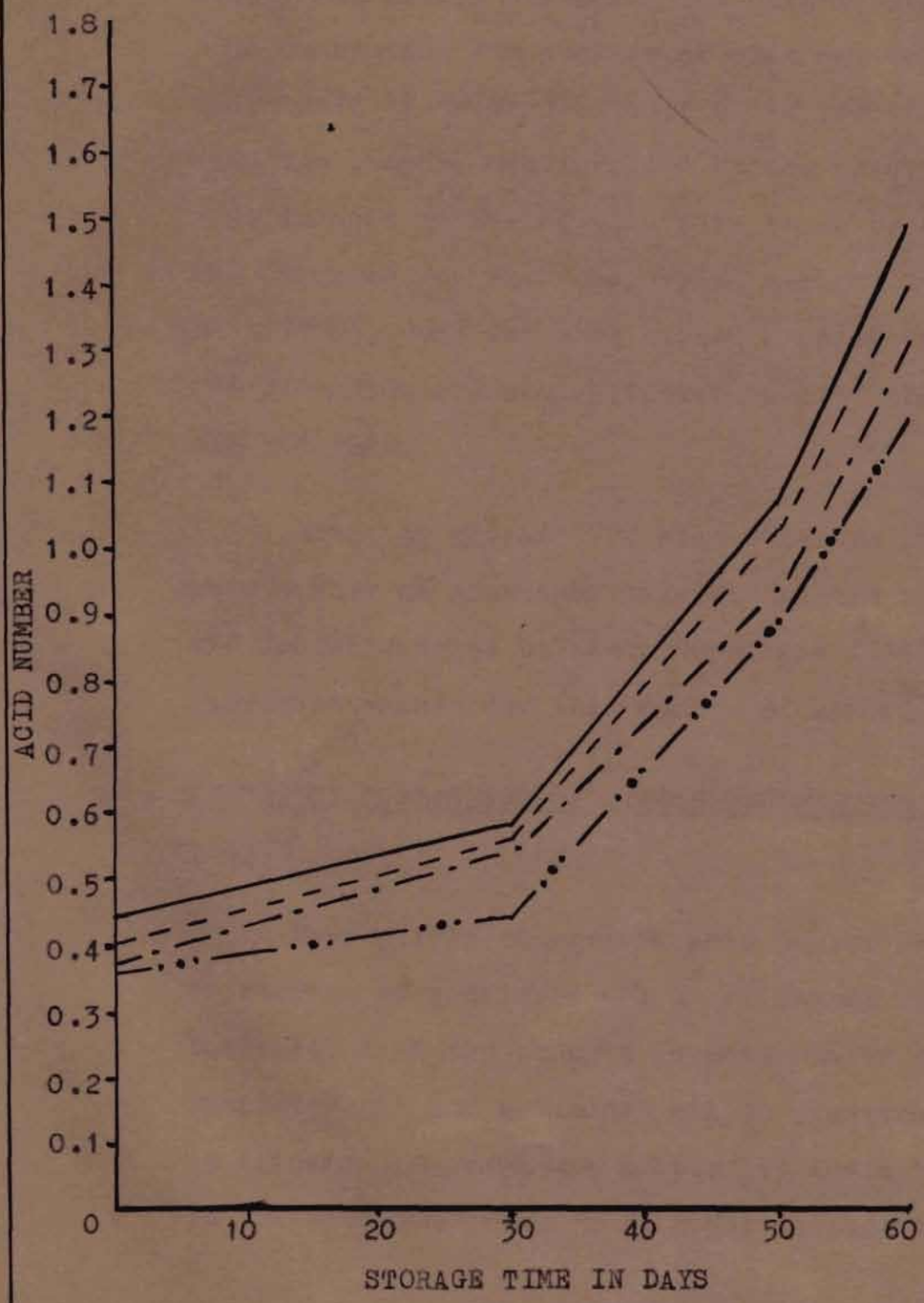
———— Groundnut oil heated for 1½ hr

- - - - - Groundnut oil heated for 1 hr

.-.-.-.-.- Groundnut oil heated for ½ hr

—...—... Fresh groundnut oil

CHANGES IN ACID NUMBER ON HEATING AND STORAGE OF GROUNDNUT OIL



1 hour and 1½ hours) was 1.03, 1.09, 1.18 and 1.09 in sunflower oil and 0.84, 0.94, 0.99 and 1.04 in groundnut oil respectively. Thus the degree of deterioration of sunflower oil and groundnut oil as determined by acid number was almost similar. The slight deterioration of oils on heating and storage of oils may be due to the hydrolysis of triglycerides, in the presence of moisture, and high temperature involved during potato frying. The rise in acid number of used fats is in agreement with the previous reports. Nageswara Rao, C., and Narasinga Rao (1968), observed more marked changes in acid number for groundnut oil and safflower samples than in coconut oil and ghee.

Arya, et al., (1972) also observed increase in the acid number of groundnut oil refined and hydrogenated. The Indian Central Oilseeds Committee (1952) also reported increased values for acid number of stored oils,

EFFECT OF CONTAINERS ON STORAGE PROPERTIES OF SUNFLOWER OIL:

Very slight changes in acid number were observed on storage of sunflower oil in different containers. Table 14 gives the changes in acid number on storage of sunflower oil and groundnut oil in plastic, tin and glass containers. A graph was plotted to indicate the changes in the acid number which is given in page 72(Figure 16).

Figure 16

Key to figure 16

- - - - - - Sunflower oil stored in tin container
——————— Sunflower oil stored in glass container
⊼ ⊼ ⊼ Sunflower oil stored in plastic container
-X-X-X-X- Groundnut oil stored in tin container
—•^•—•^• Groundnut oil stored in glass container
—•—•—• Groundnut oil stored inplastic container

EFFECT OF CONTAINERS ON THE ACID NUMBER OF SUNFLOWER OIL AND GROUNDNUT OIL

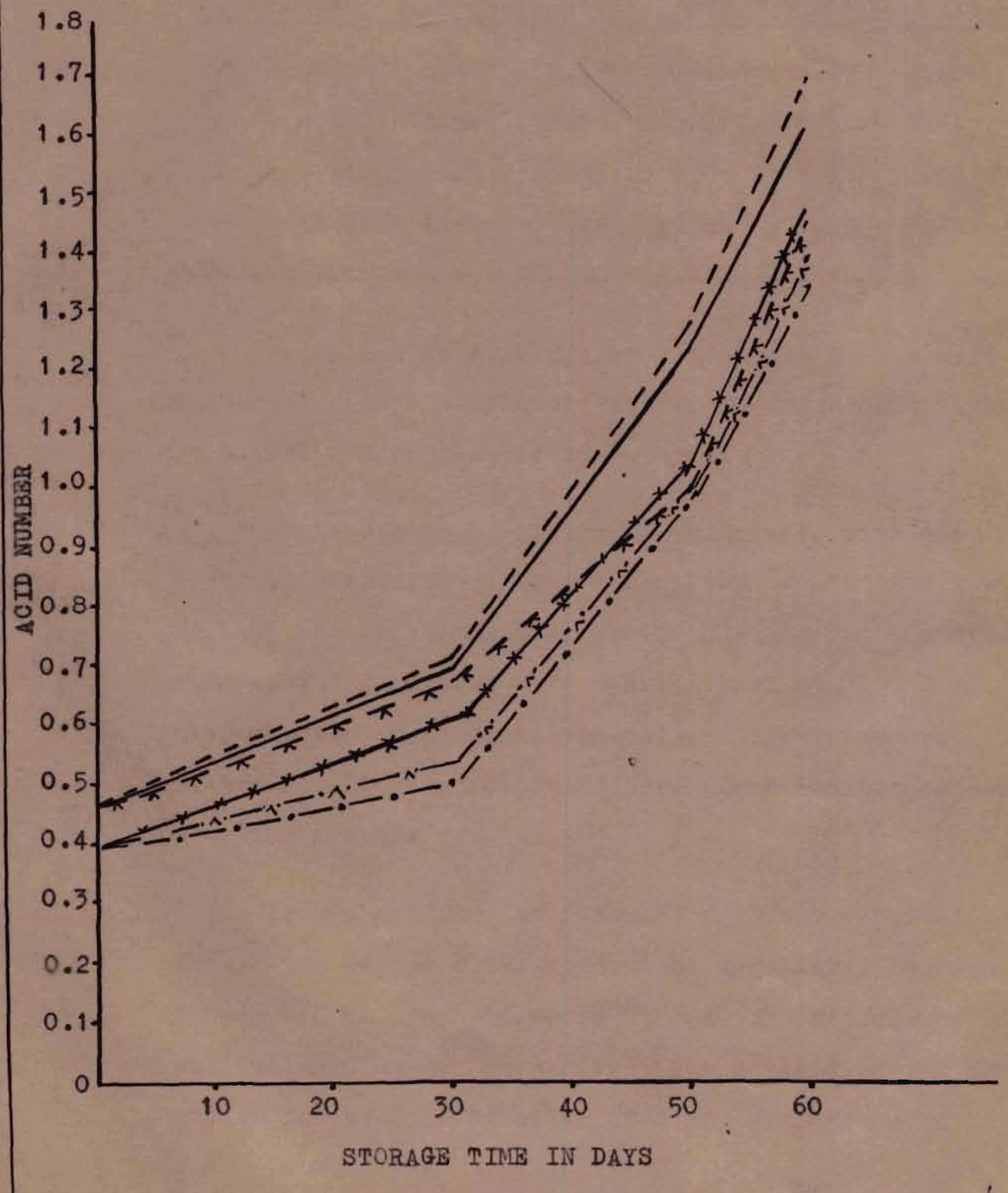


TABLE 14: EFFECT OF CONTAINERS ON THE ACID NUMBER OF STORED SUNFLOWER OIL AND GROUNDNUT OIL

Days	Milliequivalents peroxide per kilogram oil					
	Glass		Plastic		Tin	
	Sun-flower	Ground-nut	Sun-flower	Ground-nut	Sun-flower	Ground-nut
0	0.47	0.40	0.47	0.40	0.47	0.40
30	0.70	0.54	0.69	0.51	0.71	0.56
50	1.24	1.00	1.00	0.91	1.28	1.02
60	1.61	1.40	1.45	1.39	1.69	1.48

There was no significant difference in the acid number of either sunflower oil or groundnut oil, stored in glass, tin or plastic.containers.

These observations are in accordance with the observations reported by the Ministry of Food for raw, refined and groundnut oil stored in glass and tin containers for a period of 16 weeks. Paul et al., (1961) also reported that glass, porcelain, aluminium and tinned iron were good, while pot, brass and bronze were poor for storage of ghee.

From the foregoing discussion it was observed that though the degree of deterioration was higher for sunflower oil as against groundnut oil, the difference was insignificant. Secondly, plastic was a better container for storage of oils. But the difference in

peroxide value and acid number of oils stored in different containers being low, the differences were not very significant. Hydrolytic rancidity was found to occur at a faster rate as against oxidative rancidity. This probably is due to a faster rate of release of free fatty acids, than the oxidation of the fatty acids.

One of the factors influencing consumer purchase of fats and oils is its long shelf life. The quality of stored sunflower oil was found to be similar to that of groundnut oil.

SENSORY EVALUATION

An organoleptic test was conducted for deep fried, shallow fried, seasoned and baked foods and salad dressings using sunflower oil as a cooking medium. The details of scores given for each food product evaluated is given in Appendix table 29-48, pages xxxv-xLiv. Statistical analysis showed no significant difference between sunflower oil products and groundnut oil products. The results obtained by descriptive scoring were always found to coincide with the results obtained by successive rating scale, indicating that

the judges were consistent in the scoring. Comparing the total scores of sunflower oil and groundnut oil products higher scores were obtained for shallow fried, seasoned and salad dressings prepared with sunflower oil. While higher scores were obtained for deep fried products using groundnut oil and in baked preparations, the scores were almost equal. With regard to individual quality characteristics color seemed to be better for sunflower oil products as against groundnut oil products. Scores for texture of both the oil products were almost similar. There was very little variation in the scores for other quality characteristics.

DEEP FRIED FOODS:

The mean score obtained for poories and boondi prepared from sunflower oil and groundnut oil were found to be not significant, for both descriptive scoring and successive rating scale scoring as given in Appendix table 29-32, page xxxv-xxxviii. For total score of 100, the groundnut oil samples scored 96.5 and sunflower oil samples scored 95.0 for poori.

The total score obtained for the groundnut oil sample was 94.08, while that of sunflower scored 91.73 for boondi.

Vegetable oils are used in deep fat frying as medium for transference of heat and also to increase

the palatability of foods. Since deep fried products are extensively used in India, it is necessary that the sunflower oil impart the similar quality characteristics to deep fried products like any other commonly used vegetable oil. As no significant difference between the control and test samples was obtained for the two deep fried foods. The sunflower oil can enhance the sensory properties of any deep fried foods in par with the groundnut oil.

SHALLOW FRIED FOODS:

Parathas and dosas prepared with sunflower oil and groundnut oil were found to be not significant, for both descriptive scoring and successive rating scale scoring as given in Appendix table 33-36, page xxxiii-xxxiv. A total score of 96.13 were obtained for sunflower oil products, while the groundnut oil products scored 94.61 for parathas.

The total score obtained for the sunflower sample was 89.4, while the groundnut oil sample scored 85.4 for dosa.

The results of the sensory evaluation of shallow fried preparations indicate that sunflower oil is as good as groundnut oil in improving the appropriate quality characteristics of shallow fried preparations.

SEASONED PREPARATIONS:

The mean score obtained for mixed vegetable curry and sambar prepared from sunflower oil and groundnut oil were found to be not significant for both descriptive scoring and successive rating scale scoring as given in Appendix table 37-40, page xxxix-xL. The sunflower sample scored 91.6, while the control sample scored 87.6, for a total score of 100 for mixed vegetable curry.

The total score for sunflower oil product was 96.2, while that of groundnut oil product was 93.6 for sambhar.

Generally very little oil is used for seasoning of foods. The results of the sensory evaluation indicate that sunflower oil products scored higher than groundnut oil products, though the scores were not significant. Thus sunflower oil is as good as groundnut, if not better in enhancing the palatability of seasoned foods.

BAKED PRODUCTS:

The mean score obtained for cakes and biscuits prepared from hydrogenated sunflower oil and hydrogenated groundnut oil - tushar were not significant for bothdescriptive scoring and successive rating scale scoring as given in Appendix table 41-44, page xLi-xLii. Out of the total score of 100 allotted for the quality characteristics of cakes, the test sample scored 85 while the control sample scored 85.30.

The control sample scored a total of 91.63 and test sample 90.12 for biscuits.

The baked foods most commonly prepared are bread, biscuits, cakes and nan-khatai. Most of the baked foods in India are prepared commercially. A very small percentage of the Indian population prepare baked products at home. The results of sensory evaluation of baked products showed no significant difference for control and test sample. Thus hydrogenated sunflower oil can very well be used in the preparation of baked preparation. Further, an important criteria for the selection of oil for hydrogenation is its level of unsaturation. At present the oil used for hydrogenation is chiefly groundnut oil. Because of the higher unsaturation of sunflower oil as compared to groundnut oil, it can easily replace the latter oil for hydrogenation process.

SALAD DRESSINGS:

Meyonnaise sauce and vinaigrette prepared from sunflower oil and groundnut oil were found to be not significant using descriptive scoring as well as successive rating scale scoring as given in Appendix table 45-47, page xLiii-xLiv. Meyonnaise made from sunflower oil obtained a total score of 70.50 as against groundnut oil sample of 67.34.

Vinaigrette dressing prepared from groundnut oil scored 67.34 while the sunflower oil salad dressing scored 70.50 out of a total score of 100 for quality characteristics. To test the suitability of sunflower oil and for salad dressings, a chilling test was conducted. Sunflower oil remained liquid at refrigeration temperature of 40°-47°F for 24 hours. This further indicates that sunflower oil can be a good substitute for groundnut oil as well as other vegetable oils. Poor total scores were obtained for both salad dressings for both oils, because they were crude oil samples. It is necessary that oils be refined before using them for salad dressings.

Thus, the results of sensory evaluation of sunflower oil confirm that it is a good, cooking oil and salad oil.

CONSUMER ACCEPTABILITY

The questionnaire method was used to elicit information regarding the consumer acceptability of sunflower oil as a cooking medium. Particulars of the family size, age groups, education, occupation and family income of the consumers sampled in the study are tabulated in table 15, page 80. 37% of the consumers had a family consisting of 2-4 members, 46.2% had 5-7 members, 16.3% had 8-9 members and only 2.5% had a family consisting of 10 members.

The age of the consumers ranged between 20 to 25 years. Of these 22.4% were 41-45 years, 15% of the consumers were in each of the age ranges of 20-25 years and 46-50 years. 10% of the consumers were between 31 to 35 years.

All the consumers interviewed had a minimum education of middle school. 13% of the consumer population had middle school education and 13% were post-graduates. The highest percentage of consumers (32.1%) had high school education. 60% of the consumers interviewed were housewives, 20% were in teaching profession and 10% were attenders. 6% were clerks and a very small percentage (2%) of them held administrative posts.

The income range of consumers included in the study was Rs. 250-1,500. Of these 27.4% of the consumers were in the income range of Rs. 350-750 and 21% between Rs.1,000-1,500 range. 16% and 13% of the consumers were in the income range of Rs. 750-1000 and Rs. 1,500 and above respectively. 10% of the consumers had an income level between Rs. 250-350.

Edible oils preferred by the population sampled are given in Table 15. Consumer preferences of edible oils and fats is tabulated in Table 16.

36% of the consumers had first preference to safflower oil, while groundnut oil was preferred by 30%. 17% preferred sesame oil and least first preference was towards tushar, dalda and saffola. None had first preference to mustard oil, coconut oil or ghee. 26.3% and 8.7% showed second preference to dalda and groundmut oil

TABLE 15: FAMILY SIZE, AGE, EDUCATION, OCCUPATION AND INCOME OF THE CONSUMERS

Family size No. (%)	Age groups No. (%)	Education No. (%)	Occupation No. (%)	Family income (Rs.) No. (%)
28 (2-4) 37.0%	12(20-25) 15.0%	Middle school 13 (16.4%)	Housewives 48 (60.0%)	Rs. 250-350 8 (10.0%)
37 (5-7) 46.2%	18(26-30) 22.4%	High school 26 (32.1%)	Teachers 16 (20.0%)	Rs. 350-750 22 (27.6%)
13 (8-9) 16.3%	8(31-35) 10.0%	Intermediate 14 (17.5%)	Attenders 8 (10.0%)	Rs. 750-1000 16 (20.0%)
2 (10 and above) 2.5%	13(36-40) 16.3%	Graduate 14 (17.5%)	Clerks 6 (7.5%)	Rs.1000-1500 21 (26.4%)
	17(41-45) 21.3%	Post-graduate 13 (16.5%)	Administra-tors	Rs.1500 and above 12 (15.0%)
	12(46-50) 15.0%			

Total No. 80

Total % 100

TABLE 16: CONSUMER PREFERENCES OF EDIBLE FATS AND OILS

Oils	Ist preference	2nd preference	3rd preference
1.Safflower oil	31 (36.0%)	5 (6.4%)	1 (1.2%)
2.Groundnut oil	24 (30.0%)	7 (8.7%)	3 (3.8%)
3.Refined groundnut oil	6 (7.6%)	0 (0.0%)	0 (0.0%)
4. Sesame oil	11 (17.1%)	6 (7.6%)	2 (2.5%)
5.Saffola	4 (5.0%)	2 (2.5%)	0 (0.0%)
6.Dalda	3 (3.1%)	21 (26.3%)	4 (5.0%)
7.Tushar	1 (1.2%)	5 (6.3%)	3 (3.8%)
8.Mustard oil	0 (0.0%)	0 (0.0%)	0 (0.0%)
9.Ghee	0 (0%)	6 (7.6%)	1 (1.2%)
10.Coconut oil	0 (0%)	1 (1.2%)	2 (2.4%)
Total No.	80		
Total %	100		

respectively. The rest of the oils had very low second preference. Ghee had the highest third preference of 7.6%.

The results indicate that 83% of the consumer population prefer either safflower oil, groundnut oil or sesame oil. The marked preference to these oils is most probably due to the cultivation of these oilseed crops locally.

The reasons given by respondents for preference to a particular oil have been analysed and given in Table 17.

TABLE 17: REASONS FOR PREFERENCE TO A PARTICULAR OIL

Reasons for purchase	Number (percentage)
1. Habit of the family ..	59 (73.7%)
2. Good for health ..	36 (45.0%)
3. Easily available throughout the year ..	26 (32.5%)
4. Cheap ..	7 (8.7%)
5. Doctors advice ..	5 (6.2%)
6. Long shelf-life ..	1 (1.2%)
7. Does not froth on heating..	1 (1.2%)

The consumers' preference to a fat or oil was observed to be due to more than one reason. Most of the consumers (73.7%) preferred a particular oil merely because it was a habit of the family, 45% of the consumers preferred because it was good for health, while 32.5% because the oil was available throughout the year. A very small percentage

purchased an oil, either because it was cheap, on doctors advice or long shelf life and frothing was considered by a very negligible population.

Since 73.7% of the respondents purchase oil only because of habit, there may be a slight reluctance by the consumers in changing over to sunflower oil. But since 45% have indicated their choice because it is good for health and 32.5% felt availability throughout the year as the criteria for selection, these two categories may switch over if educated about nutritive value and if the oil is made easily available.

The quantity of oil purchased by the respondents in this study ranged between 3-10 kg per month. Out of them 37.5% purchased 5-6 kg oil monthly, while 32.5% purchased 3-4 kg oil monthly. 20% and 10% purchased 7-8 kg monthly and 9-10 kg oil monthly respectively.

The diets of most Indian families consists of a certain amount of fats or oils depending on their income and habit. Since the amount of oil used in seasonings is negligible, shallow fried and deep fried preparations were used as a criteria to assess the amount of oil used for these preparations. Frequency of preparation of deep fried and shallow fried preparations by the consumers was assessed, which is tabulated in Table 19. In the present study nearly 63.8% of the consumer population

prepared deep fried or shallow fried preparations as often as twice in a week, though the kind of preparation differed from family to family. This reflects the high frequency of fried foods in our diets.

TABLE 18: FREQUENCY OF CONSUMPTION OF FRIED FOODS BY THE CONSUMERS

Foods	Twice or more times a week	Once a week	Two or more times a month	Once a month	Do not prepare at all
Poorie	20(25.0%)	35(43.7%)	8(10.0%)	13(16.3%)	4(5.0%)
Vada	6(7.6%)	14(17.5%)	23(28.7%)	26(32.5%)	11(13.8%)
Murku	3(3.8%)	5(6.3%)	11(13.8%)	41(53.2%)	20(25.0%)
Sev	2(2.5%)	6(7.6%)	12(15.0%)	22(27.4%)	38(47.5%)
Bhajjiyas	9(11.2%)	17(21.2%)	19(23.7%)	17(21.3%)	18(22.4%)
Potato chips	9(11.2%)	10(12.0%)	18(22.6%)	13(16.5%)	30(37.5%)
Boondi	2(2.5%)	3(3.8%)	2(2.5%)	23(28.7%)	50(62.5%)

Among the fried foods poories were found to be prepared most frequently; 25% of the consumers prepared them twice or more times a week. Next most frequently prepared foods were bhajjiyas and potato chips. The rest of the fried foods vadas, murku, sev and boondi were prepared twice or more times a week by a very small percentage (2.5-7.6%) of the consumers. 53% of the consumers were

found to be preparing murku once a month, while about 28% of the consumers prepare vada, sev and boondi at the same frequency. 62.5% consumers do not prepare boondi at all, while 47.5%, 37.5% and 25% of the consumers do not prepare sev, potato chips, murku and bajjiyas respectively.

Thus, most frequently prepared fried foods are poorie, bajjiyas, potato chips and most rarely prepared foods are boondi, sev, vada and murku.

Table 19 gives the frequency of preparation of shallow fried foods. The most frequently prepared shallow fried food nearly twice or more times a week is chappaties, which is prepared by 93.8% of the consumers. At the same frequency dosa is prepared by 20% of the consumers and cutlets by only 25%. Dosas are prepared by 42.5% of the consumers once a week, while cutlets are prepared by 17.4% consumers.

TABLE 19: FREQUENCY OF CONSUMPTION OF SHALLOW FRIED FOODS BY THE CONSUMERS

Foods	Twice or more times a week	Once a week	Twice or more times a month	Once a month	Do not prepare
Cutlets	2(2.5%)	11(17.3%)	15(18.9%)	22(27.4%)	30(37.5%)
Dosa	16(20.0%)	34(42.5%)	13(16.3%)	3(3.8%)	14(17.5%)
Chappatis	17(93.8%)	3(3.8%)	0(0%)	1(1.2%)	1(1.2%)

The results of the consumer assessment of the quality of sunflower oil in comparison with the oil the respondents

use at home is presented in Table 20. Majority of the consumers stated that sunflower oil is similar to either safflower oil, groundnut or sesame oil. Furthermore, the difference in the sensory evaluation of safflower oil and groundnut oil being not significant, sunflower oil is likely to be accepted as a suitable oil for cooking purposes.

The earlier part of the study indicated that 85% of the consumers purchased a particular oil because it was a habit of the family. Even then 57.5% of the consumers liked the sunflower oil, while 37.5% neither liked nor disliked it and 5% disliked sunflower oil. A large percentage of the consumer population are aware of sunflower oil as a cooking medium. But a large gap exists between the awareness and acceptance of a new food like sunflower oil. This gap should be bridged by convincing the consumers that the quality of sunflower oil resembles other vegetable oils and its nutritive value is superior to other vegetable oils, except that of safflower oil. Food practices are strongly guided by the habit and it would take quite sometime before there is a total acceptance and complete change over to sunflower oil.

71.3% of the consumer population were willing to change over to sunflower oil, while 28.7% were unwilling to do so. Among the consumers who were willing to change

TABLE 20: ACCEPTANCE OF THE QUALITY CHARACTERISTICS OF SUNFLOWER OIL PRODUCTS

Foods	Grading	Color	Appearance	Flavor	Taste
Poorie	Better	15 (18.6%)	17 (20.9%)	15 (18.7%)	14 (17.5%)
	Similar	65 (81.3%)	63 (79.1%)	71 (76.3%)	64 (80.0%)
	Worse	0 (0%)	0 (0%)	4 (5.0%)	2 (2.5%)
Papads	Better	16 (20.0%)	16 (20.0%)	12 (15.0%)	13 (16.3%)
	Similar	64 (80.0%)	64 (80.0%)	63 (78.7%)	66 (82.5%)
	Worse	0 (0%)	0 (0%)	5 (6.3%)	1 (1.2%)
Chappati	Better	12 (15.0%)	12 (15.0%)	10 (12.2%)	10 (12.2%)
	Similar	67 (83.8%)	67 (83.8%)	63 (79.1%)	65 (81.3%)
	Worse	1 (1.2%)	1 (1.2%)	7 (8.7%)	5 (6.5%)
Beans curry	Better	8 (10.0%)	8 (10.0%)	8 (10.0%)	7 (8.7%)
	Similar	72 (90.0%)	72 (90.0%)	70 (87.5%)	72 (90.0%)
	Worse	0 (0%)	0 (0%)	2 (2.5%)	1 (1.2%)
Total No.		80			
Total %		100			

over, 63.7% were prepared to change over if the cost of sunflower oil is not higher than the cost of oil they are now using. 26.3% and 10% of the consumers were ready to pay 25 P and 50 P respectively more per kg., for sunflower oil.

Generally it is the middle and high income groups, which consume large quantities of fats and oils. Because of the limited supply of sunflower oil, more of middle and high income groups were included in the study. Consumer education given to high income groups regarding the nutritive value of sunflower oil and by keeping the cost of sunflower oil at a low level (as is possible), both these income groups will gradually change over to sunflower oil. Superior nutritive value continued with low cost price would be the basic requirement for the ready acceptance of sunflower into the market.

SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSION

Sunflowers are more productive than groundnut, the major kharif oil seed crop, in the areas of uncertain rainfall. Also, sunflower oil, as judged by the linoleic acid content, is reported to be of high quality. Hence the present study on the composition, storage and acceptability of sunflower as a cooking medium in comparison with groundnut oil.

The linoleic fraction of sunflower oil from Hyderabad was observed to be far less than the Canadian sample, probably due to the warm temperatures at Hyderabad. The groundnut oil sample recorded a lower linoleic fraction than sunflower oil from Hyderabad. The iodine value and refractive index of both sunflower oil samples were almost identical, but higher than the groundnut oil sample.

There was a decrease in the linoleic acid fraction and increase in the oleic acid fraction on heating sunflower oil and groundnut oil; there was no change in the level of saturated acids. The destruction of linoleic acid was higher in sunflower oil in the first half hour of heating, but on heating for one and a half hours the destruction was more in groundnut oil.

Food products such as murku, boondi and potato chips fried in sunflower oil absorbed more oil than those fried in

groundnut oil. Poorie absorbed less of sunflower oil, than others.

Storage behaviour of both the oils was determined. Accelerated rancidity test indicated that sunflower oil became rancid at a faster rate than groundnut oil. However after 14 days, the peroxide value of both the oil samples was more or less similar.

Sunflower oil stored at room temperature recorded a slightly higher peroxide value and acid number throughout the storage period than groundnut oil. For both the oil samples hydrolytic rancidity was more pronounced than oxidative rancidity.

There was no differential effect of containers - tin, glass or plastic - on oxidative and hydrolytic rancidities.

Sensory evaluation of deep fried, shallow fried, seasoned, baked products and salad dressings prepared from sunflower revealed no significant differences from those prepared from groundnut oil. No significant differences between the oils was observed either in the individual quality characteristics of food or in the total score.

A study on the consumer acceptability of sunflower oil revealed that most of the consumers felt that the cooking quality of sunflower was similar to safflower, groundnut and sesame oil. 95% of the consumer population found that the quality characteristic of sunflower oil was similar to the

oil they were using at home. 57.5% liked sunflower oil, 37.5% neither liked nor disliked sunflower oil and 5% disliked sunflower oil as a cooking medium. 63.7% were willing to buy sunflower oil if the price is no more than that of the oil they are used to, while a small percentage were willing to pay 25 paise and 50 paise extra per kilogram sunflower oil. Because people are traditionally oriented in their food patterns, it would take some time before there is a total change and complete acceptance of sunflower oil as a cooking medium.

Major cultivation of sunflower will be in the kharif season and the present studies clearly indicate that the merit of sunflowers over groundnut is largely because of higher productivity. The quality of sunflower oil of "Armaveric" variety from the kharif crop is only marginally superior to groundnut oil. It is therefore suggested, that the following be investigated:-

1. the fatty acid composition of the other sunflower varieties grown in kharif season,
2. the effect of season on the linoleic acid fraction in the different sunflower varieties,
3. the testing of sunflowers in the rabi areas where safflower is the traditional crop for yield and quality of oil and
4. consumer acceptability of sunflower oil in different regions of the country.

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APPENDICES

TABLE 1: STANDARDIZED RECIPE FOR POORIE

Ingredients	Quantity(gm)	Method
Wheat flour	250	1. Mix scieved flour, salt and 1 tsp. oil.
Salt	2	
Cold water	162 ml	2. Make a soft dough by mixing the dry ingredients and water.
Oil	300 ml	
		3. Keep the dough aside for 30 minutes in a covered vessel. Knead for two minutes.
		4. Divide the dough into 24 portions. Each portion being about 17 gm.
		5. Roll the dough into circular puri form.
		6. Heat oil in a deep fat frying pan to a temperature of 200°C.
		7. Fry the puri for one minute. Drain the oil well and remove from fire.

1. Weight of dough .. 415 gm
2. Frying time .. 1 minute
3. Yield .. 24 puries
4. Weight of each puri .. 15 gm

TABLE 2: STANDARDIZED RECIPE FOR BOONDI.

Ingredients	Quantity(gm)	Method
Begal gram flour	100	1.Scieve the dry ingredients together.
Salt	5	2.Add water to make a batter of pouring consistency.
Chilli powder	2	3.Heat oil in a frying pan to 180°C.
Oil	300 ml	4.Pour batter in a steel strainer having 40 holes (10/ sq".) each hole being of 3 mm.
Water	120 ml	
		5.Drop the batter through the holes into the heated oil.
		6.Fry boondi for ½ minute.
		7.Strain the oil from boondi for ½ minute, before removing from fire.

1. Temperature of oil .. 180°C
2. Duration of frying boondi ½ minute
3. Weight of boondi .. 80 gm

TABLE 3: STANDARDIZED RECIPE FOR POTATO CHIPS

Ingredients	Quantity(gm)	Method
Potatoes(peeled)	200	1.Peel potatoes and slice into thick and 2" in diameter.
Salt	15	
Potassium meta bi-sulphite	1	2.Add salt and potassium meta bi-sulphite to the water.
Water	300 ml	3.Shake the potato slices in salt water for 30 minutes.
Oil	300 ml	
		4.Remove the potato slices from water and dry them in a dry cloth for about 5 minutes.
		5.Heat oil to 180°C and fry 15 chips at a time for 3 minutes.

1.Temperature of oil	..	180°C
2.Duration of frying a batch of chips	..	3 minutes
3.Weight of total chips after frying	..	40 gm

TABLE 4: STANDARDIZED RECIPE FOR MURKU

Ingredients	Quantity(gm)	Method
Besan	75	1.Scieve the dry ingredients together.
Rice flour	200	
Salt	5	2.Make a soft dough by mixing the dry ingredients, 20 g oil and water.
Turmeric	2	
Chilli powder	4	3.Grease the murku moulds and add a portion of the dough into it.
Oil	300 ml	
Water	120 ml	4.On a piece of paper trace the dough into a murku pattern.
		5.Heat oil in a deep fat frying pan to a temperature of 175°C.
		6.Fry the murku for 2 minutes. Drain the oil well and remove from fire.

1. Weight of dough .. 467 gm
2. Frying time .. 2 min.
3. Yield .. 15
4. Weight of each murku .. 20 gm

TABLE 5: RECOGNITION AND SENSITIVITY TESTS

Taste	Concentration	Recognition threshold	Sensitivity threshold
1. Sweet	.0001		
	.001		
	.01		
	.1		
	.25		
	.5		
2. Salt	.0001		
	.001		
	.01		
	.1		
	.25		
	.5		
3. Sour	.0001		
	.001		
	.01		
	.1		
	.25		
	.5		
4. Bitter	.0001		
	.001		
	.01		
	.1		
	.25		
	.5		

DUO-TRIO TEST

Name:

Date:

Test the control sample and later the next two samples. One of the given sample is from the same lot, the other is from the different lot. Check the samples that are alike. Then indicate which sample(s) you prefer.

Sample:

_____ _____ are alike

_____ is different

I prefer sample(s) _____

I have no preferance _____

TRIANGLE TEST

Name:

Date:

Two of the given samples are from the same lot, the other is from the different lot. Check the 2 that are alike. Then indicate which of the sample(s) you prefer.

Sample:

_____ _____ are alike

_____ is different

I have no preference _____

I prefer sample(s) _____

TABLE 6: STANDARDIZED RECIPE FOR CHAPPATI

Ingredients	Quantity(gm)	Method
Flour	165	1.Mix scieved flour, salt and 1½ tsp. of oil together.
Salt	5	
Water	105 ml	2.Add water and make a soft dough.
Oil	50	3.Keep the dough aside for one and a half hours in a covered container.
		4.Divide the dough into six portions of 45 gm each.
		5.Roll the dough into a circular using a small quantity of dry flour.
		6.Grease the chappati and fold into half, fold once again to make a triangular shape. Turn in the edges.
		7.Roll out the dough into a circular chappati form.
		8.Heat a tava and roast the chappati for 3 minutes.
		9.Spread ½ tsp. oil on either side of chappati before removing from flame.

1. Weight of total dough .. 270 gm
2. Weight of dough per chappati 45 gm
3. Frying time .. .. 3 minutes
4. Total yield .. .. 6 chappati
5. Weight of each chappati .. 42 gm

TABLE 7: STANDARDIZED RECIPE FOR DOSA

Ingredients	Quantity(gm)	Method
Rice	220	1. Soak black gram dal and rice separately for 3 hrs.
Black gram dal	50	
Salt	5	2. Grind black gram dal and rice separately to a fine smooth consistency. Mix both in a vessel.
Water	150 ml	
Oil	120	3. Allow the batter to ferment for 17 hours. Add salt and water and mix thoroughly.
		4. Heat tewa and slightly grease it.
		5. Take a deep round spoonful of batter and make a dosa of 10" diameter on the tava.
		6. Put 1 tsp. oil round the dosa and leave it for one minute. Turn and leave for one more minute.
		7. When the dosa has a uniform golden brown colour, fold and remove the dosa from fire.

1. Weight of batter .. 676 gm
2. Weight of batter per dosa 55 gm
3. Cooking time of dosa .. 2 minutes
4. Total yield .. 12 dosa

TABLE 8: STANDARDIZED RECIPE FOR MIXED VEGETABLE CURRY

Ingredients	Quantity(gm)	Method
Potatoes	300	1.Pressure cook potatoes, carrots, peas and beans.
Carrots	150	
Peas	40	2.Cut potatoes to 1.5 sq.cm. approximately. Cut carrots and beans to approximately 1 sq.cm. Chap tomatoes finely.
Beans	40	
Oil	20	
Mustard	5	3.Slice onions into thin portions.
Black gram dal	10	4.Heat oil, add onions, curry leaves, coriander leaves and fry till the onions are slightly brown.
Turmeric	1	
Coriander powder	5	
Chilli powder	10	5.Add turmeric, chilli and coriander powder and salt. Fry for 2 minutes.
Salt	12	
Onions	40	6.Add the remaining vegetables and continue frying for 3 minutes. Remove from flame.
Tomatoes	50 gm	

1. Weight of the vegetable curry .. 570 gm
2. Cooking time .. .. 10 min.

TABLE 9: STANDARDIZED RECIPE FOR SAMBAR

Ingredients	Quantity(gm)	Method
Red gram dal	40	1.Pressure cook the dal in 300 ml water. Mash dal into a fine paste.
Onions	20	
Drumsticks	100	2.Add coriander powder, chilli powder, turmeric, salt, tamarind extract, and ground coconut.
Tamarind	10	
Chilli powder	5	
Turmeric	2	3.Cut drumsticks into a length of 5 cm. Chop onions into 1 sq.cm.
Salt	15	
Coriander powder	5	4.Add drumsticks and chopped onions to the mashed dal.
Black pepper	5	5.Allow it to boil till the drumsticks are cooked.
Dry coconut	10	
Oil	15	6.Remove and season with mustard, black gram dal, curry leaves and coriander leaves.
Coriander	15	
Cumin	3	
Mustard	3	
Water	600 ml	

1. Weight of sambar .. 280 gm
2. Cooking time .. 30 minutes.

TABLE 10: STANDARDIZED RECIPE FOR SPONGE CAKE

Ingredients	Quantity(gm)	Method
Maida	120	1.Scieve flour, salt and baking powder.
Fat	60	
Castor sugar	130	2.Cream butter and sugar till light and fluffy for 40 minutes.
Egg	2	
Vanilla	8 drops	3.Beat egg to a stiff froth. Add vanilla drops.
Rex (Baking powder)	5	4.Add beaten egg to the creamed mixture little by little beating all the time.
Salt	4	
Milk	150 ml	5.Fold in flour gently with pallate knife.
		6.Add milk to bring the mixture to a dropping consistency.
		7.Put the mixture in the gleased tin and level properly so as to leave a depression in the centre.
		8.Bake at 175°C for about 40 minutes.
		9.Cool on rack after backing.

Creaming time	..	40 minutes
Weight of batter	..	480 gms
Weight of cake	..	440 gms

TABLE 11: STANDARDIZED RECIPE FOR SWEET BISCUITS

Ingredients	Quantity(gm)	Method
Maida	250	1. Sift the flour with baking powder, salt and powdered sugar.
Powdered sugar	150	
Salt	2	2. Mix fat gently into flour, using finger tips for 3 minutes.
Baking powder	7	
Fat	150	3. Make a soft dough using water.
Cold water	70 ml	
		4. Roll the dough lightly into ½ cm thickness.
		5. Cut into rounds using biscuit cutter of 5½ cm diameter.
		6. Prick the biscuits.
		7. Bake at 150°C for 20 minutes.

1. Weight of biscuits .. 400 gm
2. Yield .. 45 biscuits
3. Diameter of the biscuit 5½ cm
4. Thickness of the biscuit ½ cm
5. Baking time .. 20 minutes

TABLE 12: STANDARDIZED RECIPE FOR MAYONNAISE

Ingredients	Quantity(gm)	Method
Sugar	3	1.Mix sugar, salt and mustard powder in an enamel bowl.
Salt	2	
Mustard powder	2	2.Add yolk and half of the vinegar. Beat well with egg beater.
Egg yolk	1	
Vinegar	15 ml	3.Then add 2 tbsp. of oil dropurise with constant whipping.
Oil	110 ml	
		4.When the ingredients are completely mixed, add another 2 tbsp. of oil dropurise beating constantly.
		5.Add the remaining oil and vinegar alternately till oil is completed.

Beating time .. 20 minutes

Weight of mayonnaise 60 gm

TABLE 13: STANDARDIZED RECIPE FOR VINAIGRETTE DRESSING

Ingredients	Quantity(gm)	Method
Vinegar	30	1. Mix all ingredients
Groundnut oil	100	in a bowl.
Salt	5	2. Keep as cold as possi-
Pepper	3	ble.

Weight of vinaigrette dressing .. 30 gm

TABLE-14: SCORE CARD FOR THE EVALUATION OF POORIES

Name: Date:

Please tick (√) for the appropriate score.

Products	Appearance	Flavor	Texture	Taste
Control	Pale golden brown	Pleasant	Soft and puffy	Desirable
	Golden brown	Moderately pleasant	Crisp and puffy	Moderately desirable
	Off white	No flavor	Soft and not puffy	Slightly desirable
	Dull brown	Bitter flavor	Crisp and not puffy	Slightly undesirable
	Brown	Rancid	Tough	Undesirable
	Pale golden brown	Pleasant	Soft and puffy	Desirable
	Golden brown	Moderately pleasant	Crisp and puffy	Moderately desirable
	Off white	No flavor	Soft and not puffy	Slightly desirable
	Dull brown	Bitter flavor	Crisp and not puffy	Slightly undesirable
	Brown	Rancid	Tough	Undesirable

TABLE 15: SCORE CARD FOR THE EVALUATION OF THE BOONDI

Name: Date:

Please tick (√) for the appropriate score.

Products	Appearance	Color	Flavor	Texture	Taste
Control	Very good	Golden yellow	Pleasant	Very crisp	Desirable
	Good	Pale brown	Fairly pleasant	Moderately crisp	Moderately desirable
	Very fair	Very pale brown	Greasy	Not crisp	Slightly desirable
	Fair	Dark brown	Alkaline	Slightly soft	Slightly undesirable
	Poor	Very dark brown	Rancid	Soft	Undesirable
	Very good	Golden yellow	Pleasant	Very crisp	Desirable
	Good	Pale brown	Fairly pleasant	Moderately crisp	Moderately desirable
	Very fair	Very pale brown	Greasy	Not crisp	Slightly desirable
	Fair	Dark brown	Alkaline	Slightly soft	Slightly undesirable
	Poor	Very dark brown	Rancid	Soft	Undesirable

TABLE 16: SCORE CARD FOR THE EVALUATION OF PARATHAS

Name: Date:

Please tick the appropriate score (√).

Product	Appearance	Flavor	Texture	Taste	Color
	Very good	Pleasant	Very soft	Desirable	Golden brown
	Good	Fairly pleasant	Moderately soft	Moderately desirable	Pale golden brown
	Very fair	No flavor	Slightly firm and crisp	Slightly desirable	Dull brown
	Fair	Greasy	Slightly firm and not crisp	Slightly undesirable	Brown
	Poor	Rancid	Very firm and crisp	Undesirable	Dark brown
	Very good	Pleasant	Very soft	Desirable	Golden brown
	Good	Fairly pleasant	Moderately soft	Moderately desirable	Pale golden brown
	Very fair	No flavor	Slightly firm and crisp	Slightly desirable	Dull brown
	Fair	Greasy	Slightly firm and not crisp	Slightly undesirable	Brown
	Poor	Rancid	Very firm and crisp	Undesirable	Dark brown

TABLE 17: SCORE CARD FOR THE EVALUATION OF DOSA

Name: Date:

Please tick (√) for the appropriate score.

Products	Appearance	Color	Flavor	Texture	Taste
	Very good	Golden brown	Pleasant flavor	Crisp	Desirable
	Good	Pale brown	Fairly pleasant	Crisp but slightly	Moderately desirable
	Very fair	Off white	Flavor	Soft	Slightly desirable
	Fair	Brown	Neutral flavor	Soft but slightly	Slightly undesirable
	Poor	Dark brown	Greasy flavor	Rubbery	Undesirable
			Rancid flavor		
	Very good	Golden brown	Pleasant flavor	Crisp	Desirable
	Good	Pale brown	Fairly pleasant	Crisp but slightly	Moderately desirable
	Very fair	Off white	Flavor	Soft	Slightly desirable
	Fair	Brown	Neutral flavor	Soft but slightly	Slightly undesirable
	Poor	Dark brown	Greasy flavor	Rubbery	Undesirable
			Rancid flavor		

TABLE 18: SCORE CARD FOR THE EVALUATION OF MIXED VEGETABLE CURRY

Name: Date:

Please tick(√)for the appropriate score.

Products	Appearance and color	Flavor	Tenderness	Taste
	Pleasant combination of colors	Mild and pleasant	Tender	Very good
	Fairly pleasant combination of colors	Very little flavor	Moderately tender	Good
	Neither pleasant nor unpleasant	Strong spicy flavor	Fairly tender	Very fair
	Slightly unpleasant combination of colors	Foreign flavor	Slightly tough	Fair
	Unpleasant combination of colors	Bitter flavor	Tough	Poor
	Pleasant combination of colors	Mild and pleasant	Tender	Very good
	Fairly pleasant combination of colors	Very little flavor	Moderately tender	Good
	Neither pleasant nor unpleasant	Strong spicy flavor	Fairly tender	Very fair
	Slightly unpleasant combination of colors	Foreign flavor	Slightly tough	Fair
	Unpleasant combination of colors	Bitter flavor	Tough	Poor

TABLE 19: SCORE CARD FOR THE EVALUATION OF SAMBAR

Name: Date:

Please tick (√) for the appropriate score.

Products	Appearance	Color	Flavor	Consistency	Taste
	Very good	Pleasing yellow brown	Moderate and pleasing	Smooth and pouring	Desirable
	Good	Dull yellow brown	Tee strong and	Slightly creasy	Moderately desirable
	Very fair	Slightly dark brown	Slight flavor	Slightly creasy & thick	Slightly desirable
	Fair	Dark brown	Bitter flavor	Too thin and watery	Slightly undesirable
	Poor	Brownish black	Rancid flavor	Too thick & dropping	Undesirable
	Very good	Pleasing yellow brown	Moderate and pleasing	Smooth and pouring	Desirable
	Good	Dull yellow brown	Tee strong and	Slightly creasy	Moderately desirable
	Very fair	Slightly dark brown	Slight flavor	Slightly creasy & thick	Slightly desirable
	Fair	Dark brown	Bitter flavor	Too thin & watery	Slightly undesirable
	Poor	Brownish black	Rancid flavor	Too thick & dropping	Undesirable

TABLE 20: SCORE CARD FOR THE EVALUATION OF CAKES

Name: Date:

Please tick (√) the appropriate score.

Products	Crust color	Flavor	Taste	Texture
	Rich golden brown	Mild sweet flavor	Very good	Light spongy
	Pale golden brown	Rich sweet flavor	Good	Not very spongy
	Slightly brown	Foreign flavor	Very fair	Too spongy
	Brown	No flavor	Fair	Slightly heavy
	Dark brown	Unpleasant flavor	Poor	Heavy
	Rich golden brown	Mild sweet flavor	Very good	Light spongy
	Pale golden brown	Rich sweet flavor	Good	Not very spongy
	Slightly brown	Foreign flavor	Very fair	Too spongy
	Brown	No flavor	Fair	Slightly heavy
	Dark brown	Unpleasant flavor	Poor	Heavy

TABLE 21: SCORE CARD FOR THE EVALUATION OF BISCUITS

Name: Date:

Please tick (√) the appropriate score.

Products	Appearance	Color	Flavor	Texture	Taste
	Excellent	Pale golden brown	Desirable	Gas holes small and uniform	Desirable
	Very good	Dark golden brown	Moderately desirable	Gas holes slightly small and uniform	Moderately desirable
	Good	Slightly brownish black	Slightly desirable	Gas holes moderately small and uniform	Slightly desirable
	Very fair	Moderately brownish black	Slightly undesirable	Gas holes big and uniform	Slightly undesirable
	Fair	Brownish black	Undesirable	Gas holes big and not uniform	Undesirable
	Excellent	Pale golden brown	Desirable	Gas holes small and uniform	Desirable
	Very good	Dark golden brown	Moderately desirable	Gas holes slightly small and uniform	Moderately desirable
	Good	Slightly brownish black	Slightly desirable	Gas holes moderately small and uniform	Slightly desirable
	Very fair	Moderately brownish black	Slightly undesirable	Gas holes big and uniform	Slightly undesirable
	Fair	Brownish black	Undesirable	Gas holes big and not uniform	Undesirable

TABLE 22: SCORE CARD FOR THE EVALUATION OF MAYONNAISE

Name: Date:

Please tick the appropriate score (√).

Products	Appearance (Max.30)	Flavor (Max.20)	Consistency (Max. 30)	Taste (Max.20)
	Desirable	Pleasant	Creamy	Excellent
	Moderately desirable	Moderately pleasant	Moderately creamy	Very good
	Slightly desirable	Slightly pleasant	Slightly creamy	Good
	Slightly undesirable	Slightly unpleasant	Slightly pouring	Very fair
	Undesirable	Unpleasant	Pouring	Fair
	Desirable	Pleasant	Creamy	Excellent
	Moderately desirable	Moderately pleasant	Moderately creamy	Very good
	Slightly desirable	Slightly pleasant	Slightly creamy	Good
	Slightly undesirable	Slightly unpleasant	Slightly pouring	Very fair
	Undesirable	Unpleasant	Pouring	Fair

TABLE 23: SCORE CARD FOR THE SENSORY EVALUATION OF VINAIGRETTE

Please tick the appropriate score (√). Name: Date:

Products	Appearance (Max.30)	Flavor (Max. 20)	Consistency (Max. 30)	Taste (Max.20)
	Desirable	Pleasant	Creamy	Excellent
	Moderately desirable	Moderately pleasant	Moderately creamy	Very good
	Slightly desirable	Slightly pleasant	Slightly creamy	Good
	Slightly undesirable	Slightly unpleasant	Slightly pouring	Very fair
	Undesirable	Unpleasant	Pouring	Fair
	Desirable	Pleasant	Creamy	Excellent
	Moderately desirable	Moderately pleasant	Moderately creamy	Very good
	Slightly desirable	Slightly pleasant	Slightly creamy	Good
	Slightly undesirable	Slightly unpleasant	Slightly pouring	Very fair
	Undesirable	Unpleasant	Pouring	Fair

TABLE 24: SUCCESSIVE RATING SCALE FOR MEASUREMENT OF FOOD ACCEPTANCE

Name: Code: Date:

Quality judgement(check one)	Like-dislike affect (check one)
1. Extremely poor	Dislike extremely
2. Very poor	Dislike very much
3. Poor	Dislike moderately
4. Below fair-above poor	Dislike slightly
5. Fair	Neither like nor dislike
6. Below good-above fair	Like slightly
7. Good	Like moderately
8. Very good	Like very much
9. Excellent	Like extremely

SUCCESSIVE RATING SCALE FOR MEASUREMENT OF FOOD ACCEPTANCE

Name: Code: Date:

Quality judgement (check one)	Like-dislike affect (check one)
1. Extremely poor	Dislike extremely
2. Very poor	Dislike very much
3. Poor	Dislike very much/moderately
4. Below fair-above poor	Dislike slightly
5. Fair	Neither like nor dislike
6. Below good-above fair	Like slightly
7. Good	Like moderately
8. Very good	Like very much
9. Excellent	Like extremely

QUESTIONNAIREE TO FIND OUT THE CONSUMER ACCEPTABILITY OF SUNFLOWER OIL

1) Name .. :

2) Date .. :

3) Address .. :

4) Family size: (a) Adults :
(b) Children :

5) Occupation .. :

6) Total monthly income from: all sources

7) Education .. :

8) Tick the age group to which you belong:

(a) 20-25 years (b) 26-30 years (c) 31-35 years
(d) 36-40 years (e) 41-45 years (f) 46 years & above

9+) Indicate in the order of maximum consumption the oils used often in your home:

(a) Til oil (b) Groundnut oil (c) Mustard oil
(d) Kusum oil (e) Dalda (f) Tushar
(g) Saffola (h) Any other.

10) Indicate the oils used rarely in your home:

(a) Til oil (b) Groundnut oil (c) Mustard oil
(d) Musum oil (e) Dalda (f) Tushar
(g) Safollar (h) Any other

11) Tick the reason(s) for your purchase of a particular type of oil:

(a) Cheap
(b) Easily available throughout the year
(c) Habit of the family
(d) Good for health
(e) Oil-seeds are grown in your farm
(f) Doctor's advice
(g) Any other

12) What is the quantity of oil consumed in your home?

(a) 3-4 kg (b) 5-6 kg
(c) 7-8 kg (d) 9-10 kg

13) Have you heard of sunflower oil as a cooking medium?

Yes/No

14) If 'Yes' what is your source of information?

(a) News papers (b) Radio talks
(c) Magazines (d) Personal communication
(e) Any other

15) Indicate the deep fried foods prepared in your home and their frequency of consumption:-

Food item	Daily	Twice or more times a week	Once a week	Two or more times a month	Once a month
(a) Poorie					
(b) Vadaa					
(c) Murku					
(d) Sev					
(e) Bajjiyas					
(f) Potato-chips					
(g) Boondi					

16) Indicate the shallow fried foods prepared in your home and the frequency of consumption:

Food item	Daily	Twice or more times a week	Once a week	Two or more times a month	Once a week
(a) Cutlets					
(b) Dosa					
(c) Chappatis					

17) Tick the appropriate physical characteristics of the sunflower oil sample given to you:

(a)	COLOR	: Pleasing	Neutral	Not pleasing
(b)	CLARITY	: Clear	Suspended material	Muddy
(c)	FLAVOR	: Agreeable	Neutral	Disagreeable
(d)	OILYNESS	: Not noticeable	Just right	Too oily
(e)	VISCOSITY	: Too thin	Just right	Too thick

18) Use the sunflower oil sample in preparing the following dishes:

(a) Poorie (b) Papad
(c) Chappati (d) Beans curry

and give your opinion on the following:

Cooking quality	Deep frying	Shallow frying	Seasoning
(a) Does the oil froth on heating?	Yes/No	Yes/No	Yes/No
(b) Does the oil fume on heating?	Yes/No	Yes/No	Yes/No
(c) Does the oil impart the right color to the preparation?	Yes/No	Yes/No	Yes/No
(d) Has the oil a tendency to impart oilyness to the preparation?	Yes/No	Yes/No	Yes/No
(e) Is the taste of the preparation satisfactory?	Yes/No	Yes/No	Yes/No

19) Compare the preparations made by using sunflower oil with the oil used in your home and assess the following characteristics:

Items prepared with sunflower oil	Quality-characteristics	Color	Appearance	Flavor	Taste
(a) Poorie	Better Similar Worse				
(b) Papads	Better Similar Worse				
(c) Chappati	Better Similar Worse				
(d) Beans curry					

20) To which oil(s) in your opinion is unflower oil comparable?

(a) Groundnut oil
(b) Til oil
(c) Kusum oil
(d) Saffola
(e) Any other

21) Do you (a) Like the sunflower oil?
(b) Neither like nor dislike?
(c) Dislike the sunflower oil?

22) If you like the sunflower oil tick the reasons for your liking:

(a) Pleasing color
(b) Agreeable flavor
(c) Less absorbed by the foods
(d) It is good for health
(e) Any other

23) If you dislike the sunflower oil tick the reasons for your dislike:

(a) Unpleasant flavor
(b) Unpleasant color
(c) Too oily
(d) Any other

24) Would you like to change over to sunflower oil?

Yes/No

25) Would you be willing to buy sunflower oil if it is available in the market at the same price as the oil you purchase?

Yes/No

26) Would you be willing to buy sunflower oil if it were costlier than the oil you purchase by

(a) 25 Ps per kg
(b) 50 Ps per kg
(c) 75 Ps per kg
(d) Not willing to buy at an extra cost.

TABLE 25: INCREASE IN PEROXIDE VALUE OF SUNFLOWER OIL ON STORAGE

No.of days	Treatment	Glass	Plastic	Tin	Treatment average
0	Fresh oil	nil	nil	nil	nil
	Oil heated for ½ hr	"	"	"	"
	Oil heated for 1 hr	"	"	"	"
	Oil heated for 1½ hr	"	"	"	"
	Container average	"	"	"	"
30	Fresh oil	0.46	0.48	0.52	0.48
	Oil heated for ½ hr	0.52	0.54	0.56	0.54
	Oil heated for 1 hr	0.54	0.57	0.59	0.57
	Oil heated for 1½ hr	0.57	0.59	0.61	0.59
	Container average	0.52	0.54	0.57	-
50	Fresh oil	0.80	0.75	0.83	0.79
	Oil heated for ½ hr	0.90	0.84	0.92	0.89
	Oil heated for 1 hr	0.92	0.85	0.95	0.91
	Oil heated for 1½ hr	1.00	0.90	1.00	0.97
	Container average	0.90	0.84	0.92	-
60	Fresh oil	1.16	1.00	1.15	1.10
	Oil heated for ½ hr	1.20	1.04	1.14	1.12
	Oil heated for 1 hr	1.22	1.08	1.16	1.21
	Oil heated for 1½ hr	1.28	1.12	1.16	1.23
	Container average	1.19	1.06	1.15	-

TABLE 26: INCREASE IN THE PEROXIDE VALUE OF GROUNDNUT OIL ON STORAGE

No.of days	Treatment	Glass	Plastic	Tin	Treatment average
0	Fresh oil	nil	nil	nil	nil
	Oil heated for ½ hr	"	"	"	"
	Oil heated for 1 hr	"	"	"	"
	Oil heated for 1½ hr	"	"	"	"
	Container average	"	"	"	-
30	Fresh oil	0.16	0.18	0.20	0.18
	Oil heated for ½ hr	0.21	0.23	0.25	0.23
	Oil heated for 1 hr	0.29	0.31	0.33	0.31
	Oil heated for 1½ hr	0.33	0.35	0.37	0.35
	Container average	0.25	0.27	0.28	-
50	Fresh oil	0.34	0.30	0.35	0.33
	Oil heated for ½ hr	0.40	0.35	0.43	0.39
	Oil heated for 1 hr	0.41	0.40	0.45	0.42
	Oil heated for 1½ hr	0.45	0.43	0.50	0.46
	Container average	0.40	0.38	0.42	-
60	Fresh oil	0.54	0.60	0.50	0.52
	Oil heated for ½ hr	0.62	0.60	0.79	0.66
	Oil heated for 1 hr	0.90	0.80	0.82	0.83
	Oil heated for 1½ hr	0.90	0.82	1.05	0.92
	Container average	0.74	0.70	0.78	-

TABLE 27: INCREASE IN THE ACID VALUE OF SUNFLOWER OIL ON STORAGE

No.of days	Treatment	Glass	Plastic	Tin	Treatment average
0	Fresh oil	0.44	0.44	0.44	0.44
	Oil heated for ½ hr	0.46	0.46	0.46	0.46
	Oil heated for 1 hr	0.49	0.49	0.49	0.49
	Oil heated for 1½ hr	0.50	0.50	0.50	0.50
	Container average	0.47	0.47	0.47	-
30	Fresh oil	0.63	0.61	0.65	0.63
	Oil heated for ½ hr	0.72	0.68	0.73	0.71
	Oil heated for 1 hr	0.73	0.69	0.75	0.72
	Oil heated for 1½ hr	0.80	0.73	0.82	0.80
	Container average	0.71	0.69	0.73	-
50	Fresh oil	0.90	0.81	1.00	0.90
	Oil heated for ½ hr	1.05	0.96	1.02	1.01
	Oil heated for 1 hr	1.50	1.02	1.53	1.35
	Oil heated for 1½ hr	1.53	1.05	1.56	1.37
	Container average	1.24	0.96	1.28	-
60	Fresh oil	1.51	1.30	1.62	1.47
	Oil heated for ½ hr	1.53	1.55	1.57	1.55
	Oil heated for 1 hr	1.62	1.68	1.73	1.67
	Oil heated for 1½ hr	1.68	1.70	1.73	1.71
	Container average	1.61	1.64	1.69	-

TABLE 28: INCREASE IN THE ACID NUMBER OF GROUNDNUT OIL ON STORAGE

No.of days		Glass	Plastic	Tin	Treatment average
0	Fresh oil	0.36	0.36	0.36	0.36
	Oil heated for ½ hr	0.38	0.38	0.38	0.38
	Oil heated for 1½ hr	0.41	0.41	0.41	0.41
	Oil heated for 1½ hr	0.45	0.45	0.45	0.45
	Container average	0.40	0.40	0.40	-
30	Fresh oil	0.45	0.43	0.47	0.45
	Oil heated for ½ hr	0.55	0.53	0.57	0.55
	Oil heated for 1 hr	0.57	0.55	0.59	0.57
	Oil heated for 1½ hr	0.58	0.56	0.60	0.58
	Container average	0.54	0.51	0.56	-
50	Fresh oil	0.90	0.87	0.92	0.89
	Oil heated for ½ hr	0.98	0.90	0.95	0.94
	Oil heated for 1 hr	1.01	1.01	1.06	1.02
	Oil heated for 1½ hr	1.08	1.05	1.09	1.07
	Container average	0.99	0.96	1.00	-
60	Fresh oil	1.17	1.23	1.19	1.20
	Oil heated for ½ hr	1.34	1.34	1.29	1.32
	Oil heated for 1 hr	1.51	1.40	1.30	1.40
	Oil heated for 1½ hr	1.50	1.48	1.49	1.49
	Container average	1.39	1.48	1.40	-

TABLE 29: MEAN SCORES OBTAINED BY DESCRIPTIVE SCORING FOR POORIES

Food products	Appearance (Max.30)	Flavor (Max.20)	Texture (Max.30)	Taste (Max.20)	Overall acceptability (Max.100)	Remarks
Control sample	27.76	19.50	49.26	20.00	96.50	N.S.
Test sample	26.26	17.00	49.26	18.50	95.00	N.S.
't' value	0.48	1.52	0.0	1.02	0.90	

TABLE 30: MEAN SCORES OBTAINED BY SUCCESSIVE RATING SCALE FOR POORIES

Food products		Quality (Max. 20)	Like/Dislike (Max.20)	Remarks
Test sample	..	17.50	17.63	N.S.
Control sample	..	15.00	16.00	N.S.
't' value	..	1.51	0.73	

TABLE 31: MEAN SCORES OBTAINED BY DESCRIPTIVE SCORING FOR BOONDI

Food products	Appearance (Max.25)	Color (Max.20)	Flavor (Max.10)	Texture (Max.30)	Taste (Max.15)	Overall acceptability (Max.100)	Remarks
Control sample	24.38	19.50	9.50	27.50	13.20	94.08	N.S.
Test sample	24.38	19.00	9.00	26.75	12.60	91.73	N.S.
't' value	0.0	0.30	0.40	0.40	0.44	0.32	

TABLE 32: MEAN SCORES OBTAINED BY SUCCESSIVE RATING SCORE FOR BOONDI

Food products		Quality (Max. 20)	Like/Dislike (Max. 20)	Remarks
Control sample	..	18.20	17.25	N.S.
Test sample	..	18.00	16.50	N.S.
't' value	..	1.00	0.50	

TABLE 33: MEAN SCORES OBTAINED BY DESCRIPTIVE SCORING FOR PARATHAS

Food products	Appearance (Max.30)	Flavor (Max.10)	Texture (Max.25)	Taste (Max.15)	Color (Max.20)	Overall acceptability (Max. 20)	Remarks
Control sample	26.25	9.00	24.38	12.38	19.00	94.61	N.S.
Test sample	27.50	9.50	24.38	15.00	19.50	96.13	N.S.
't' value	0.40	0.40	0.0	1.93	0.30	0.36	

TABLE 34: MEAN SCORES OBTAINED BY SUCCESSIVE RATING SCORE FOR PARATHAS

Food products		Quality (Max. 20)	Like/Dislike (Max. 20)	Remarks
Control sample	..	10.75	12.75	N.S.
Test sample	..	12.75	13.50	N.S.
't' value	..	0.55	0.21	

TABLE 35: MEAN SCORE OBTAINED BY DESCRIPTIVE SCORING FOR DOSA

Food products	Appearance (Max.25)	Color (Max.20)	Flavor (Max.10)	Texture (Max.30)	Taste (Max.15)	Overall acceptability (Max. 100)	Remarks
Control sample	19.00	15.00	6.80	26.00	12.00	85.40	N.S.
Test sample	21.00	18.00	9.00	26.00	12.00	89.40	N.S.
't' value	0.94	0.50	0.63	0.0	0.0	0.09	

TABLE 36: MEAN SCORES OBTAINED BY SUCCESSIVE RATING SCALE FOR DOSA

Food products	Quality (Max. 20)	Like/Dislike (Max. 20)	Remarks
Control sample ..	15.60	14.00	N.S.
Test sample ..	18.00	18.00	N.S.
't' value ..	2.20	1.29	

TABLE 37: MEAN SCORES OBTAINED BY DESCRIPTIVE SCORING FOR MIXED VEGETABLE CURRY

Food products	Appearance & color(Max.30)	Flavor (Max.20)	Tenderness (Max.20)	Taste (Max.30)	Overall acceptability(Max.100)	Remarks
Control sample	28.80	19.60	16.80	25.20	87.60	N.S.
Test sample	30.00	19.60	16.80	27.40	91.60	N.S.
't' value	1.00	0.0	0.0	0.44	0.91	

TABLE 38: MEAN SCORES OBTAINED BY SUCCESSIVE RATING SCALE FOR MIXED VEGETABLE CURRY

Food products		Quality (Max.20)	Like/Dislike (Max.20)	Remarks
Control sample	..	13.20	15.00	N.S.
Test sample	..	15.60	16.20	N.S.
't' value	..	1.78	0.66	

TABLE 39: MEAN SCORES OBTAINED BY DESCRIPTIVE SCORING FOR SAMBAR

Food products	Appearance (Max. 30)	Color (Max.10)	Flavor (Max.25)	Consistency (Max.15)	Taste (Max.20)	Overall acceptability (Max.100)	Remarks
Control sample	28.00	9.80	24.00	13.80	19.20	93.60	N.S.
Test sample	27.00	10.00	25.00	15.00	19.00	96.20	N.S.
't' value	0.57	1.00	1.00	1.00	0.0	0.47	

TABLE 40: MEAN SCORES OBTAINED BY SUCCESSIVE RATING SCALE FOR SAMBAR

Food products		Quality (Max.20)	Like/Dislike (Max. 20)	Remarks
Control sample	..	16.20	17.40	N.S.
Test sample	..	16.80	18.00	N.S.
't' value	..	0.42	1.00	

TABLE 41: MEAN SCORES OBTAINED BY DESCRIPTIVE SCORING FOR CAKES

Food products	Color (Max.30)	Flavor (Max.20)	Texture (Max.30)	Taste (Max.20)	Overall acceptability (Max. 40)	Remarks
Control sample	28.50	17.50	24.00	16.50	85.30	N.S.
Test sample	25.50	18.50	25.40	16.00	85.00	N.S.
't' value	1.08	0.48	0.30	0.18	0.21	

TABLE 42: MEAN SCORES OBTAINED BY SUCCESSIVE RATING SCALE FOR CAKES

Food products		Quality (Max. 20)	Like/Dislike (Max.20)	Remarks
Control sample	..	16.13	16.13	N.S.
Test sample	..	15.25	15.25	N.S.
't' value	..	0.40	0.40	

TABLE 43: MEAN SCORES OBTAINED BY DESCRIPTIVE SCORING FOR BISCUITS

Food products	Appearance (Max.15)	Color (Max.20)	Flavor (Max.10)	Texture (Max. 30)	Taste (Max.25)	+Overall acceptability (Max.100)	Remarks
Control sample	13.50	14.63	10.00	28.13	25.00	91.63	N.S.
Test sample	15.00	15.00	9.25	26.25	23.12	90.12	N.S.
't' value	0.76	0.49	0.71	0.61	0.71	0.75	

TABLE 44: MEAN SCORES OBTAINED BY SUCCESSIVE RATING SCORE FOR BISCUITS

Food products		Quality (Max. 20)	Like/Dislike (Max.20)	Remarks
Control sample	..	17.00	17.25	N.S.
Test sample	..	16.25	16.75	N.S.
't' value	..	0.54	0.34	

TABLE 45: MEAN SCORES OBTAINED BY DESCRIPTIVE SCORING FOR MAYONNAISE

Food products	Appearance (Max. 30)	Flavor (Max.20)	Consistency (Max.20)	Taste (Max.30)	Overall acceptability (Max. 100)	Remarks
Control sample	16.40	16.50	14.26	15.50	67.34	N.S.
Test sample	23.00	16.26	24.00	17.00	70.50	N.S.
't' value	1.39	0.04	1.24	0.36	0.82	

TABLE 46: MEAN SCORES OBTAINED BY SUCCESSIVE RATING SCALE FOR MAYONNAISE

Food products	Quality (Max. 20)	Like/Dislike (Max.20)	Remarks
Control sample ..	15.25	15.25	N.S.
Test sample ..	16.23	16.23	N.S.
't' value ..	0.40	0.40	

TABLE 47: MEAN SCORE OBTAINED BY DESCRIPTIVE SCORING FOR VINAIGRETTE

Food products	Appearance (Max.30)	Flavor (Max.20)	Consistency (Max. 20)	Taste (Max.30)	Overall acceptability (Max.100)	Remarks
Control sample	15.50	14.20	16.50	16.40	67.34	N.S.
Test sample	17.00	16.26	16.26	23.00	70.50	N.S.
't' value	0.36	1.24	0.04	1.39	0.82	

TABLE 48: MEAN SCORE OBTAINED BY SUCCESSIVE RATING SCALE FOR VINAIGRETTE

Food products		Quality (Max.20)	Like/Dislike (Max. 20)	Remarks
Control sample	..	15.25	15.25	N.S.
Test sample	..	16.23	16.23	N.S.
't' value	..	0.40	0.40	

Fig.1

SUNFLOWER OIL

(SOURCE: HYDERABAD)

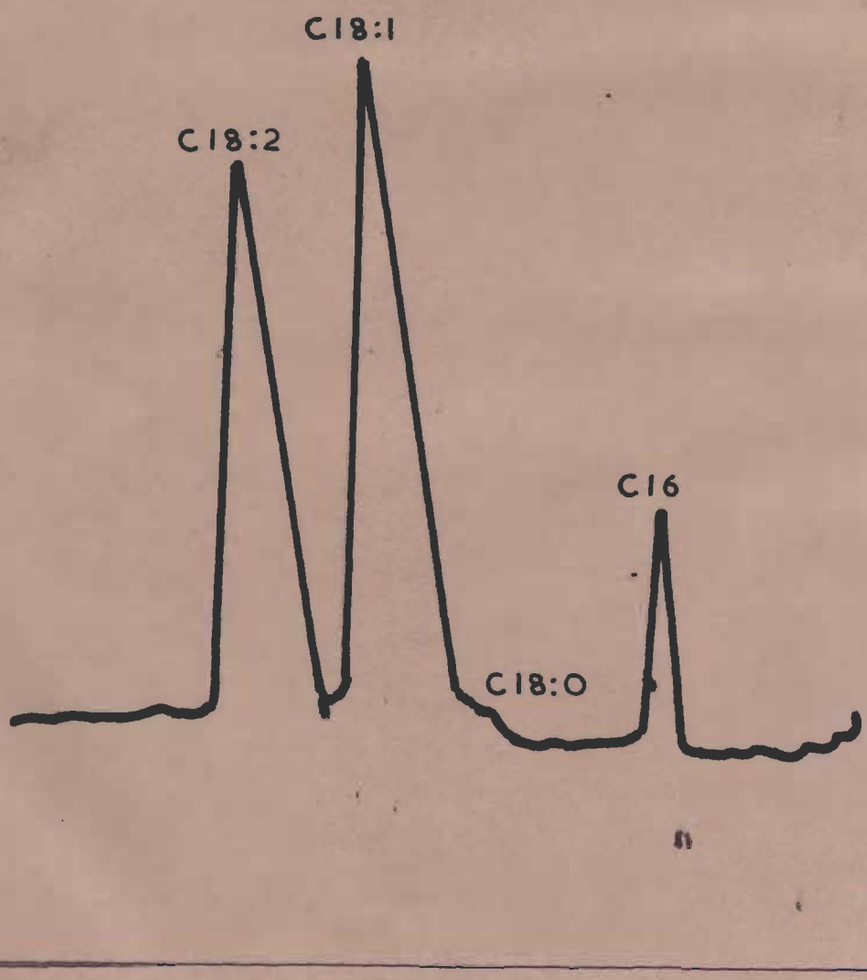

Fig.2 (xLvi)

SUNFLOWER OIL

(SOURCE : CANADA)

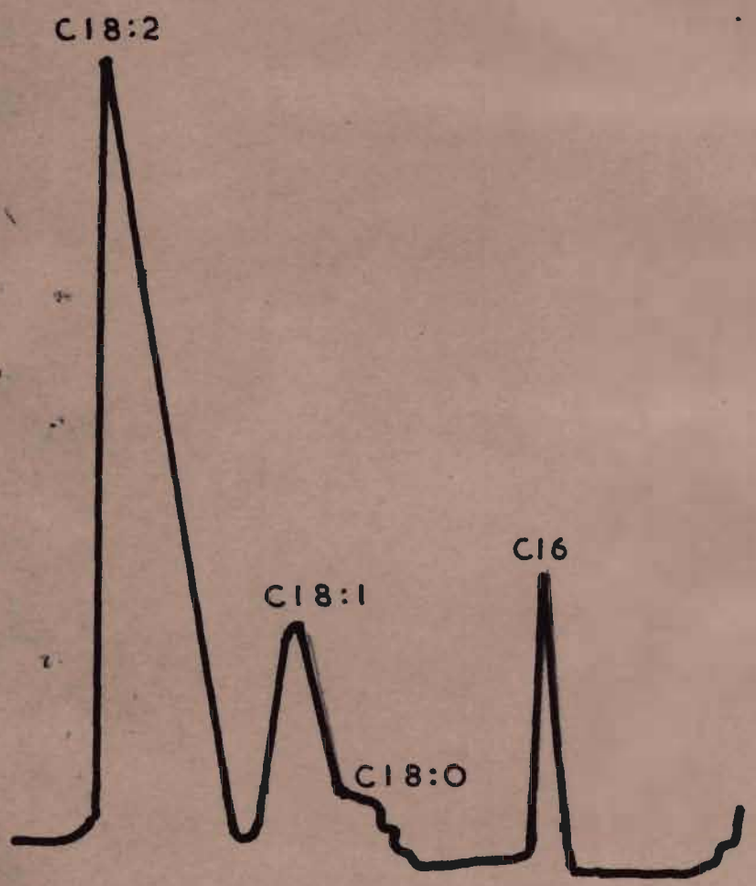

Fig.3 (xLvii)

HYDROGENATED SUNFLOWER OIL

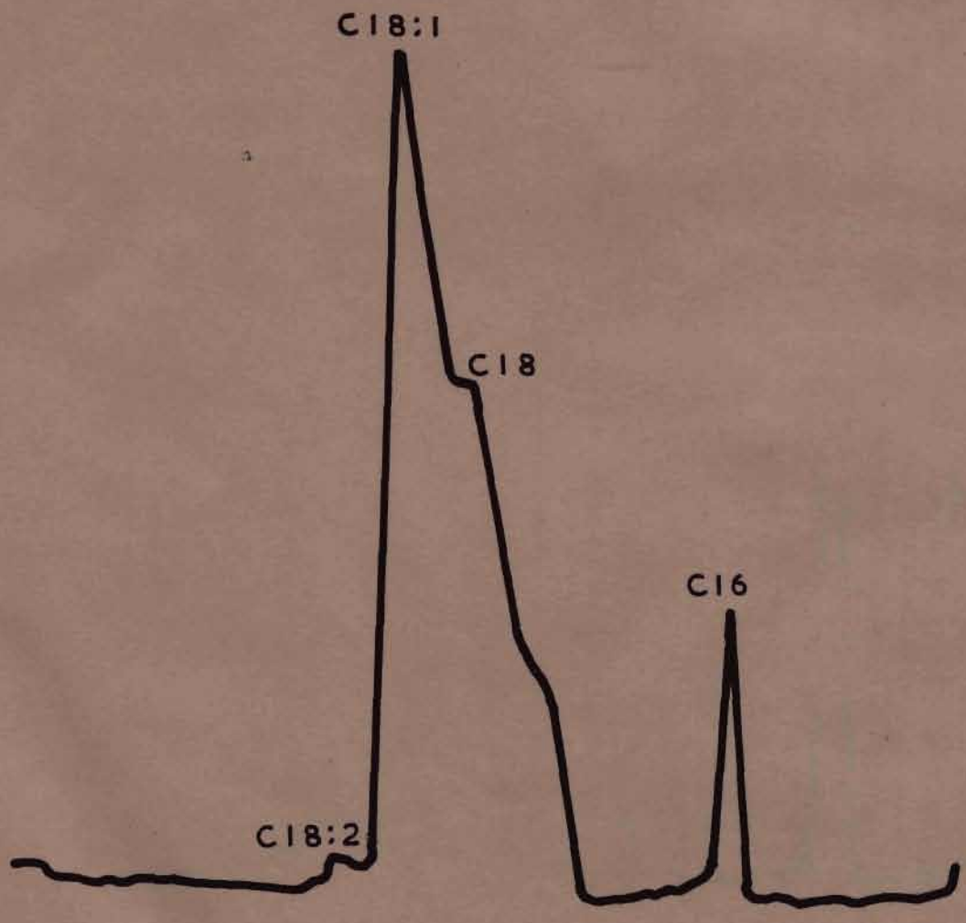

Fig.4 (xLviii)

GROUNDNUT OIL

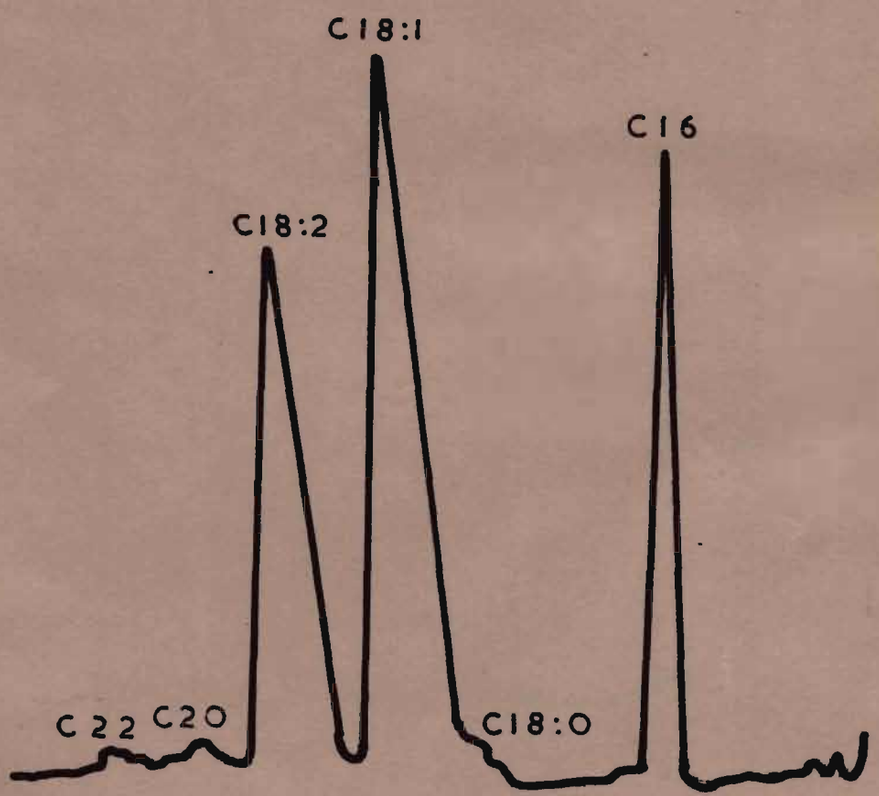

Fig.5 (xLix)

SUNFLOWER OIL HEATED FOR 'HALF AN HOUR

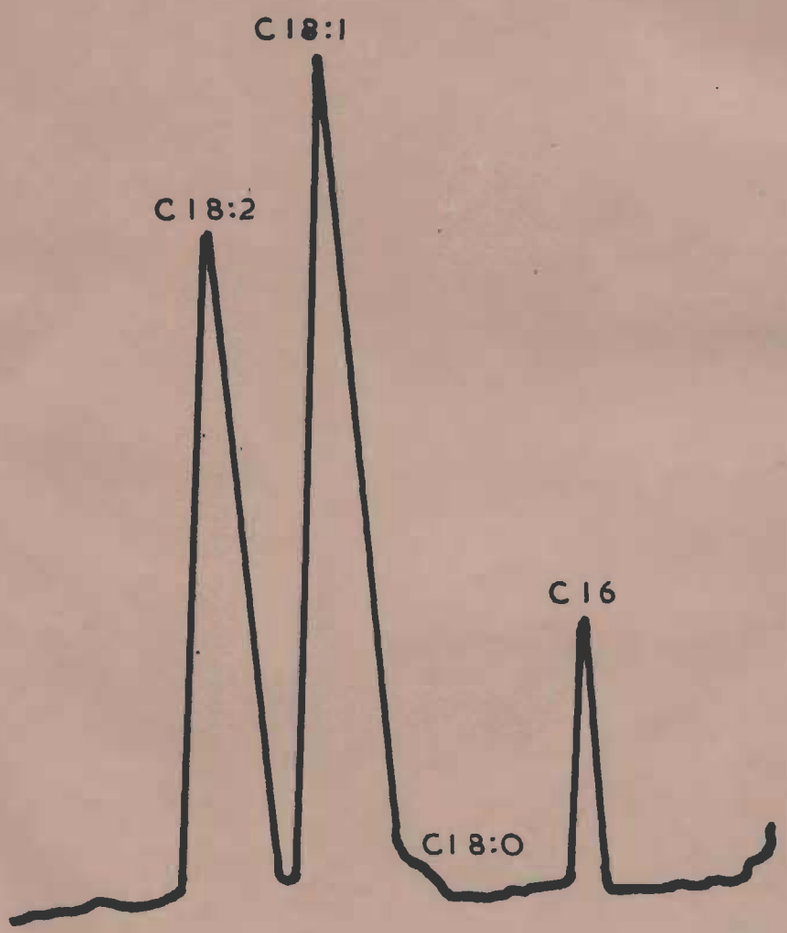

Fig.6 (L)

SUNFLOWER OIL HEATED FOR ONE HOUR

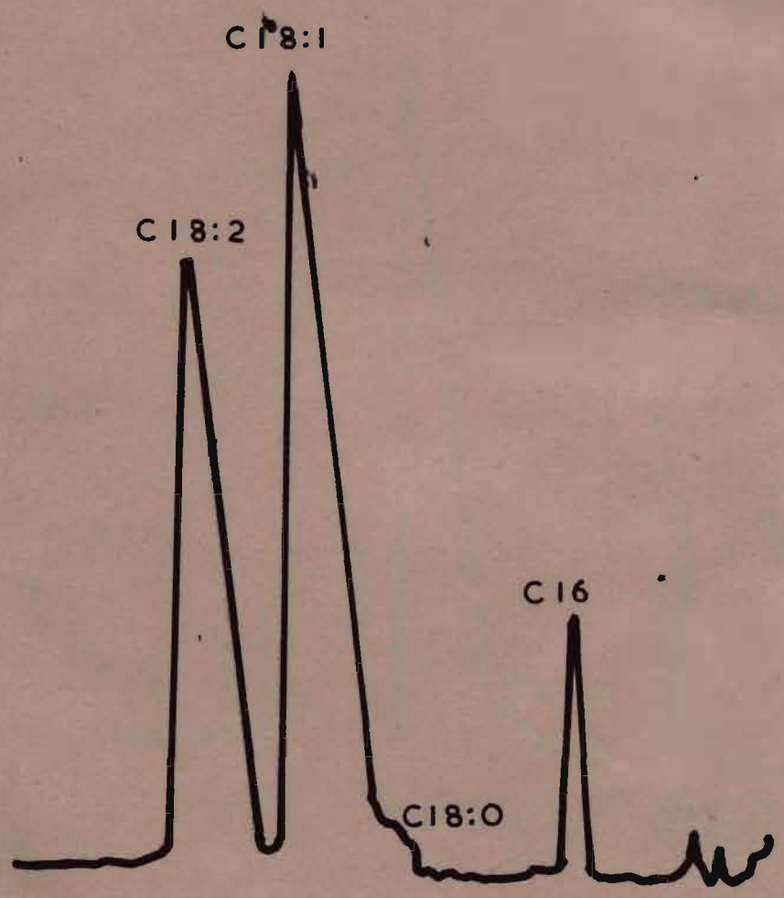

Fig.7 (Li)

SUNFLOWER OIL HEATED FOR ONE AND A HALF HOURS

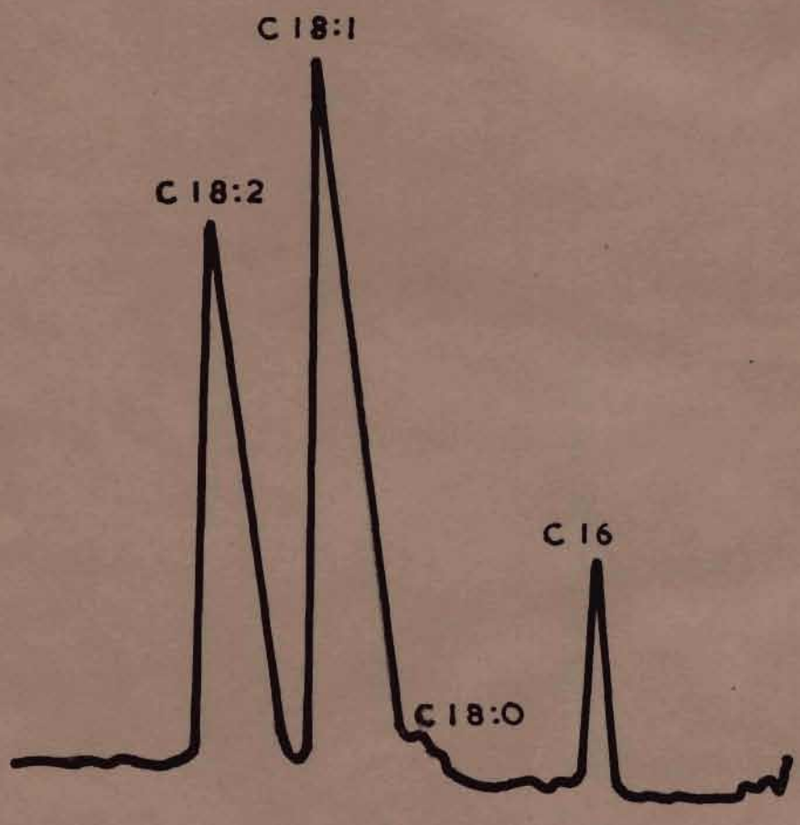

Fig.8 (Lii)

GROUNDNUT OIL HEATED FOR HALF AN HOUR

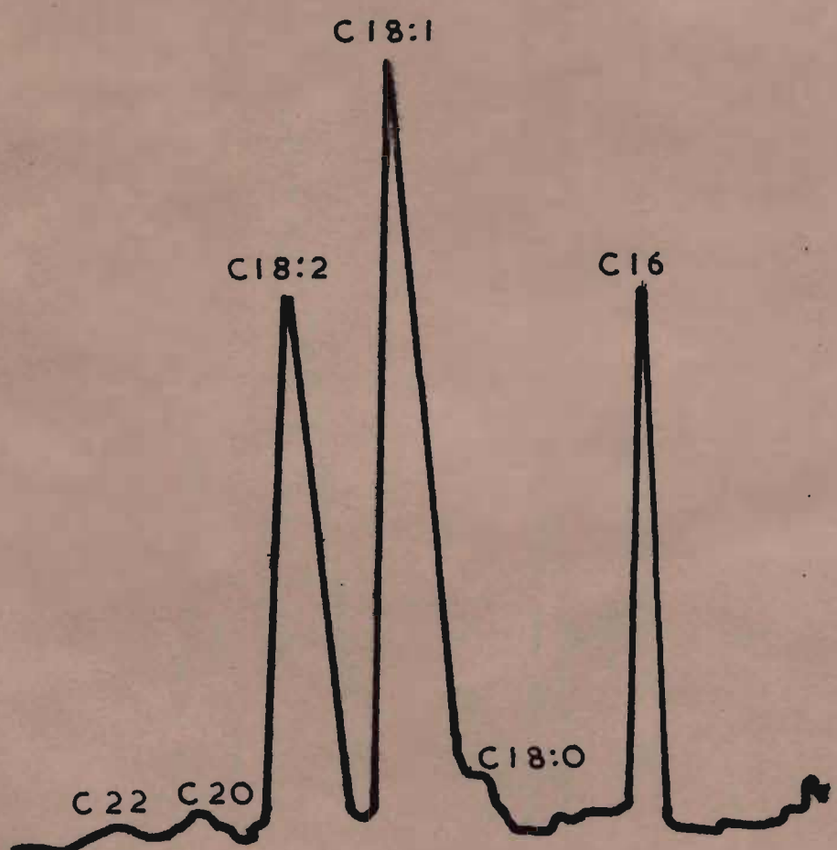

Fig.9 (Liii)

GROUNDNUT OIL HEATED FOR ONE HOUR

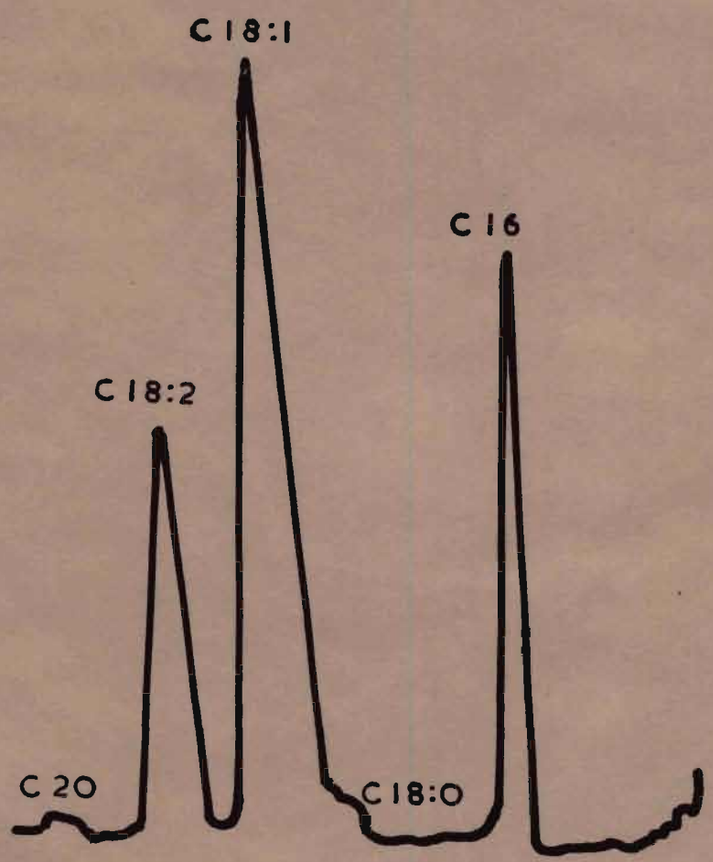

Fig.10 (Liv)

GROUNDNUT OIL HEATED FOR ONE & HALF HOURS