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Research Unit
College of Home Science
Nirmala Niketan
49, New Marine Lines
Mumbai - 400 020

For Subscription to the journal and other particulars, kindly contact:

The Principal,
College of Home Science,
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Mumbai-400020
India
E-mail : nnchsc@bom5.vsnl.net.in
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RESEARCH REACH -
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EDITORIAL

It is indeed gratifying to note that the journal has been well received by the fraternity of Home scientists and nutritionists, Textile technologists and others.

In response to the requests from the readers it has been decided to dedicate alternate issues to specific topics in one area of specialization. Thus the present issue has been solely devoted to "Fats and Oils" focusing on the profile of edible oils.

As the Subject is very vast with the varieties of edible oils marketed today and the chemical and clinical researches available on the therapeutic values of these oils, it has not been possible to give full justice to the topic fats and oils. Hence in this issue it has been decided to give the profile of selected oils covering the history, physical and chemical properties and their nutritional/therapeutic values.

Therefore the next issue of the Journal will include research papers in all the areas of Home Science. Research articles are invited for the next issue as usual and the instructions to the authors are also given as a ready reckoner.

G.Subbulakshmi
Chief editor

INSTRUCTIONS TO THE AUTHORS

Research Reach – Journal of Home Science started in 2001, is an unique publication encompassing all branches of Home Science under one cover and entails original and authentic Research and Development work from all branches of Home Science. It is an bi-annual publication from Research Unit of College of Home Science, Nirmala Niketan, 49, New Marine Lines, Mumbai–400020.

The format of the journal includes:

1. Review paper on specific topics of current trends pertaining to Home Science. It should be around 12 –16 pages.
2. Research papers with a maximum of 6-10 pages.
3. Research notes limited to a maximum of 2- 4 pages.
4. Paper / Book Review of not more than 1 page each.

The Paper should be sent by e-mail. Please also send 2 hard copies neatly printed on one side. Please follow the model from Research Reach. The article should cover:

Title: Title of the paper with the names of authors and the name of the department/ University should be given.

Abstract: Give an abstract of about 100-150 words reporting concisely the objectives, approach and the principal findings.

Text: The text can follow the abstract in the same page with introduction, materials and methods, results, discussion, conclusion, acknowledgement if any and references.

References: should be cited at the appropriate point in the text by giving author's name and year.

Follow a standard journal such as JFST for citing references.

Example: Phadke NY, Gholap AS, Ramakrishnan K, Subbulakshmi G (1994) Essential oil of Decalepis hamiltonii as an antimicrobial agent. J. Food Sci. Technol. 31(6): 472-475.

The data reported should be authentic and original with clear objectives, materials used, methods employed and the results obtained. It should not have been published or offered for publication elsewhere. The author should give an undertaking in writing to this effect

The editorial board deserves the right to edit the manuscripts in order to make them suitable for publication in the journal and the judgment of the reviewing expert regarding the quality of the paper is final.

Information / Views / Data published in the journal are of the authors only.

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FATS AND OILS: AN OVERVIEW

Oilseeds are a major cash crop for India. The country is among the largest global producers, particularly of groundnut, rapeseed and cottonseed. India accounts for 9.3 per cent of world oilseed production. It has the world's fourth largest edible oil economy. Unfortunately, India also holds another top rank, and that is in imports of vegetable oil, which constitutes about 70 per cent of India's agricultural imports. About 43 per cent of edible oil available in India is imported. In 1999, India ranked as the world's largest importer of edible oils, displacing China. The bulk of edible oil India imports under the Open General License (OGL) is RBD palmolein of Malaysian and Indonesian origin. The total import of edible oils during the period from November 1998 to October 1999 totaled 4.4 million tonnes valued at more than Rs. 9,000 crores. That was against a demand-supply gap of 1.4 million tonnes in 1998-99. The same imports rose to 6 4.71 million tonnes in the year 2003 due to falling domestic output.

This deficit is due to the lack of sufficient numbers of efficient oil mills, and the low capacity utilization in the existing ones. The crude oil refineries are also small, and hence uncompetitive. Because of the threat of increase in the international price of vegetable oils, and the removal of duties on imports, the availability of future stocks of vegetable oil may come at a heavy price. For domestic producers of vegetable oil, an easing of restrictions on import of oilseeds would be welcome, since the fluctuations and recent decline in domestic output of oilseeds along with a 40 percent duty on import of oilseeds places them in a very vulnerable position. As far as domestic production of oilseeds is concerned, the low level of irrigation in the high-producing states makes the cultivation dependent on rain. Rising input costs have also had their adverse effects.

Together, groundnut, soybean and rapeseed / mustard account for over 80 per cent of the output of cultivated oilseeds in India. Domestic edible oil production (5-6 million tonnes) is not sufficient to meet the national demand. The trade policy reforms in the mid 1990s also fuelled the increase in edible oil imports, which now meet 40-45 per cent of India's consumption requirements. India will continue to depend on imports in the future, mainly for crude palm oil / palmolein and crude soybean oil as these have been the cheapest options

Recently the interest in fats and oils has achieved the foremost attention from health point of view. Foods high in saturated (meat and dairy fat) and trans fatty acids (margarine, hydrogenated vegetable oil, and many processed foods containing hydrogenated vegetable oil) were directly associated with heart attacks and deaths from coronary heart disease. Foods high in monounsaturated fats, such as olive oil, and polyunsaturated fats, as found in nuts and most vegetable oil, have been linked to reduced risk to a great extent.

There are numerous types of oils that are used in cooking in India. Mustard oil is popular in Uttar Pradesh, Bihar, West Bengal, North Eastern States, Jammu & Kashmir, Punjab, Himachal Pradesh, and parts of Rajasthan. Groundnut oil is common in Tamilnadu, Maharashtra, Gujarat, Madhya Pradesh, Southern parts of Karnataka and Andhra Pradesh. Gingelly oil is widely used in Rajasthan, Southern parts of Tamilnadu, Andhra Pradesh and Gujarat. Coconut oil is popular in coastal areas like Goa, Kerala and Karnataka while Safflower (Kardi) is used in Marathwada area of Maharashtra and parts of Karnataka. Regional consumer preferences for certain oils are led mainly by what is grown locally (mustard/rapeseed in the north and east, groundnut in the west, soybean in the north, coconut in the south).

Being the largest importer and the third largest consumer (after China and EU) of edible oils, India is a major player in the international edible oils market. Each year, India consumes over 10 million tonnes of edible oil. However, the per capita consumption of edible oils is around 10 kg per year; this is considerably lower than in most developed countries. Per capita consumption dropped by around 3 per cent in 2002-03, mainly caused by a decrease in consumption by lower income groups. The price of edible oils is the biggest driver for consumption. There has been a continuous shift to cheaper oils such as palm oil and soybean oil. With cases of adulteration being reported practically every year in the unbranded loose oil category, a slow and steady shift towards branded oils is increasing.

Monounsaturated fat is considered beneficial when consumed in the recommended amounts (10-15 % of total calories) as they are known to help reduce the levels of LDL cholesterol without lowering the HDL cholesterol. The most widely used oils that are high in monounsaturated are olive oil, canola oil and peanut oil (Fig.1). Polyunsaturated fats, made up of omega-3 and omega-6 essential fatty acids are also considered relatively healthy and include corn, soybean, safflower, and grape seed oil. Oils high in omega-3 rich polyunsaturated fat such as flaxseed oil and canola oil are a good addition to the diet since the body requires omega-3s for good health but cannot manufacture them. Studies reveal that incorporating omega-3s into the diet reduces the risk of stroke, heart attack and heart disease.

Polyunsaturated fatty acids are considered beneficial when consumed in the recommended amounts (8-10 % of total calories). It is recommended that no more than 10 % of total calories be acquired from saturated fat. EPA (eicosapentaenoic acid) lowers LDL cholesterol and increases HDL cholesterol, decreases blood-clotting effects, has anti-arrhythmic effect and has anti-inflammatory effect (via eicosanoids, by weakening the effect of pro-inflammatory hormones). DHA (docosahexaenoic acid) high levels are required for learning, memory, and visual performance as a component of brain and retina tissues and for preventing cardiovascular disease. Also plays a vital role during pregnancy and infant development and helps in autoimmune disorders and kidney disease.

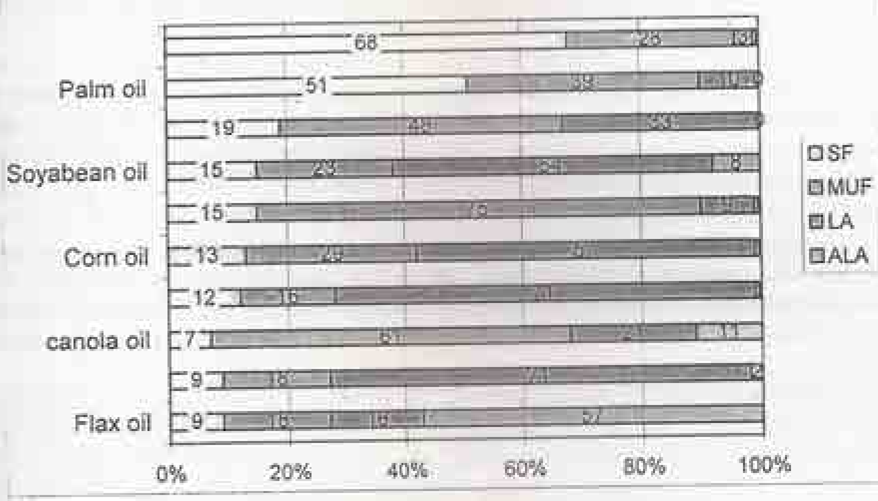
Trans-fatty acids cause more physical problems than saturated fatty acids. Saturated fats, when present in excess amounts in the diet, can cause weight gain and blood platelet stickiness. However, trans-fatty acids prevent proper cellular nutrition, affecting health at a very basic level. Dietary trans fats raise the level of LDL increasing the risk of coronary heart disease. trans fats also reduce HDL, and raise levels of triglycerides in the blood. Both of these conditions are associated with insulin resistance, which is linked to diabetes, hypertension, and cardiovascular disease. Harvard University researchers have reported that people who ate partially hydrogenated oils, which are high in trans fats, had nearly twice the risk of heart disease as compared to those who did not consume hydrogenated oils. Because of the overwhelming scientific evidence linking trans fats to cardiovascular diseases, the Food and Drug Administration will require all food labels to disclose the amount of trans fat per serving, starting in 2006.

Trans fats also have a detrimental effect on the brain and nervous system. Neural tissue consists mainly of lipids and fats. Myelin, the protective sheath that covers communicating neurons, is composed of 30% protein and 70% fat. Oleic acid and DHA are two of the principal fatty acids in myelin. Studies show that trans fatty acids in the diet get incorporated into brain cell membranes, including the myelin sheath that insulates neurons. These synthetic fats replace the natural DHA in the membrane, which affects the electrical activity of the neuron. Trans fatty acid molecules alter the ability of neurons to communicate and may cause neural degeneration and diminished mental performance. Neurodegenerative disorders such as Parkinson's and Alzheimer's appear to exhibit membrane loss of fatty acids. A Canadian study showed that an average of 7.2% of the total fatty acids of human breast milk consisted of trans fatty acids, which originated from the consumption of partially hydrogenated vegetable oils by the mothers.

Health Canada recommends a dietary Omega-6:Omega-3 ratio of 4:1 to 10:1 and Food & Agriculture Association / World Health Organization Joint Committee suggests 5:1 to 10:1 while the current dietary ratio ranges from 10:1 to 25:1. Health Canada recommends that pregnant women increase omega-3 intake by 0.05 g during 1st trimester, and by 0.16 g during 2nd and 3rd trimesters. Lactating women should consume an additional 0.25 g.

ALA is also found in the fats and oils of canola, wheat germ and soybeans; in nuts such as butternuts and walnuts and in red and black currant seeds. Other sources include omega-3 enriched eggs and breads with milled flax seeds. Up to 80% of the fatty acids in green leafy vegetables are alpha-linolenic acids. However, they have only small amounts of lipids, so leafy vegetables don't contribute significant amounts of ALA to the diet. (Table 1)

(Fig. 1) SATURATED AND UNSATURATED FATTY ACIDS IN DIETARY FATS AND OILS



Note: Linolenic and linoleic fatty acids are both polyunsaturated fatty acids (PUFA). The total of linoleic plus linolenic does not necessarily equal the total PUFA due to omission of other PUFA's and/or rounding of numbers. Alpha-linolenic acid, the omega-3 essential fatty acid, is included in the linolenic fatty acid value.

India has approximately 300 crude edible oil refining units, 60-70 per cent of which are small. Oil is extracted using one of two methods -- mechanical or chemical. Chemical extraction, often called solvent extraction, is the most common and cost efficient method. It employs high heat and a series of chemical processes, primarily exposure to hexane gas, to remove and refine the oil. In mechanical extraction, called cold pressed or expeller pressed, oil is squeezed from the source, usually with hydraulic presses. This minimal exposure to heat preserves the natural flavor of the oil but limits the yield, making mechanically extracted oils moreexpensive than chemically extracted oils.

TABLE 1 ALA CONTENT OF SOME FOODS

Oils	ALA Content (g/100 g raw oil)
Flaxseed	53.3
Canola (conventional)	9.2
Canola (high oleic)	0.1
Soybean	6.8
Rice Bran	1.6
Corn	0.9
Olive	0.5
Butterfat	0.5

Bhatty, 1995.

Just as each oil has a unique nutritional makeup, it also has distinct flavour components and smoke points, making some oils more appropriate for certain use than others.

Despite availability of increasingly sophisticated scientific testing and equipment, sensory evaluation of refined oils remains a critical indicator of quality. Although this organoleptic measurement is complex, oil exhibiting poor flavour or odour characteristics is readily recognized as objectionable by consumers.

To extend the shelf life and preserve the nutritional value of culinary oils, store them in the refrigerator once they've been opened. Oils rich in omega-3 essential fatty acids such as flax, walnut, pumpkin and other nutritional oils should be protected from heat and light whether or not they have been opened. For other types of oil, a dark, cool pantry is a good storage option.

Heating oil past its smoke point can cause it to have an off flavour, lose its nutritional value and turn the once healthy oil into a trans fat leading to heart disease. Oils that can take high temperatures make good all-purpose cooking oils. Canola, sunflower and peanut are suitable for high-heat uses such as searing and frying. Medium-high heat oils are good for baking, sautéing and stir-frying e.g. grape seed, safflower or sunflower oil. For sauces, lower-heat baking and pressure cooking, medium-high heat oils are best. Good choices are olive oil and corn oil.

Research has shown that there are oils that should never be heated. These oils, found on the supermarket shelves in the nutritional supplement category, can also be used as condiments, used in dips and dressings, or added to a dish after it has been removed from heat. For example, walnut oil, with its nutty flavor can be added to the salad. Or sesame oil can be added to the stir-fry to add extra flavor after cooking. Flax, evening primrose and wheat germ oils are the other oils to be used unheated in order to incorporate essential fatty acids in the diet.

Again from the safety point of view AICR (2004) recommends diabetics not to use fish oil supplements as they can affect blood sugar control. Individuals with bleeding disorders, and people taking blood-thinning medications such as aspirin, should not use fish oil supplements because they decrease the ability of the blood to clot. Cancer patients should get their doctor's approval before taking fish oil or any dietary supplement. Anyone who decides to take fish oil supplements should limit daily doses to 1000 mg. Their dangerous toxin content arising from current levels of water pollution is the main drawback of fish sources of omega 3's. In particular, fresh water fish are prone to the accumulation of heavy metals and pesticide contamination. Among other deleterious effects on health, these toxic chemicals have been shown to cause fetal tissue damage.

The essential fatty acids are polyunsaturated and superunsaturated. With this level of saturation, the essential fatty acids are very chemically reactive and easily destroyed by light, air and heat. When oil is bought in clear glass or plastic containers, the essential fatty acids that may exist in this oil has been changed by their exposure to light and the nutrients have also been destroyed by the heat used in the traditional oil manufacturing process. Most commercial oil industries use a high heat and chemical process to extract oils from seeds, vegetables and grains. The standard procedure is to press the seed, nut or bean, then to soak them in chemical solvents to allow more oil to be extracted. Oils are degummed, refined, then bleached. Finally, oils are deodorized using steam distillation under pressure. This process heats oils to 464° - 518° for 30 - 60 minutes. Deodorizing virtually destroys any remaining nutrients in the oil, and removes the various chemicals and peroxides that have been used during refining and bleaching.

When essential fatty acids are heated to temperatures above 320^{0}C unsaturated fatty acids become mutagenic, which means they can damage our genes (and those of our offspring). Further damage occurs at higher temperatures. When oils are heated to 320^{0}C, trans-fatty acids begin to form. The higher the temperature, the more trans-fatty acids form. High heat (in excess of 320^0 C) changes the molecular configuration of unsaturated oil. The original molecular configuration fits perfectly into enzyme and membrane structures. Though only slightly different in its structure, half of trans-fatty acid fits into those same enzyme and membranes. In this partial fit, it cannot do the work of a normal fatty acid at the same time it blocks the pathway of the normal fatty acids. They impair the protective barrier around cells, which is vital for keeping cells alive and healthy.

High heat frying and deep frying are not recommended for those on a healing diet, or for regular practice of those who are trying to maintain good health. If you choose to sauté and stir fry occasionally, Udo Erasmas and Donna Gates, author of The Body Ecology Diet, both recommend using either ghee and coconut butter. Ghee has long been revered in India for its healing properties, please see the article on page 2 for more information. Because olive oil is monounsaturated, it can be heated to 325° without destroying its fatty acids

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DIETARY FATS : TURN OF EVENTS

Sonal Modi, Valentine Borges and Hemraj Chandalia
Diabetes Endocrine Nutrition Management and Research Centre, Mumbai

The regulation of food intake is a highly complex network of feedback mechanisms. Overall, human metabolism is better equipped to counter food deprivation rather than food abundance. Hence, with an improvement in economic status and purchasing capacity of an individual, guidance is needed in the process of food selection. Although carbohydrate intake is efficiently regulated by neuropeptides and amines, fat intake is poorly regulated. Hence, a critical review of dietary fat and its role in health and disease is an extremely important facet of public awareness and education.

Historical Perspective

The relationship of dietary cholesterol and fat to atherosclerosis was established as early as 1950's by Keys (1953, 1970). This was based on the chemical analysis of a typical atherosclerotic plaque. The advent of the sixties led to the discovery of the fact that total fat and especially saturated fat (SFA) is linked to serum cholesterol. The benefits of polyunsaturated fatty acids (PUFA) and its ratio to SFA were set at 3:1. The total fat intake was advised to be at about 37- 45 % of Calories (Dayton et al. 1969).

The next decade brought a downward revision of fat to between 25-35 % of total Calories. An equal division into SFA: MUFA: PUFA was considered desirable. Certain adverse effects of PUFA were demonstrated such as ability to cause increased peroxidation and generation of free oxygen radicals (Miller et al. 1988).

The American Diebetic Association (ADA 2004) revised the ratio of dietary fat after these observations. It was revised to PUFA (6-8 %), MUFA (12-14 %) and SFA (7 %). The role and effect of omega–3 and omega–6 PUFA in cardiovascular conditions were analysed extensively.

Dietary fat, blood lipids and coronary artery disease

Various components of dietary fats may influence blood lipids and thereby promote or retard atherogenesis. Dietary fats may also have an influence on the vascular disease through other mechanisms, like oxidative stress or thrombogenic potential. Hence, the effect of dietary fats have been studied on the coronary artery disease risk factors or directly on the incidence of coronary artery disease. The effects of any parameter on the risk factors are easier to study, because the results are apparent in a short period of 2-8 weeks. The hard end-point of coronary artery disease, myocardial infarction and death has greater scientific validity, but require long-term studies of 3-5 years. When evaluating dietary intake one must keep these important facts in mind.

Although most cholesterol is endogenously synthesized in the liver, dietary cholesterol can further influence the blood cholesterol levels, mainly in the disease states. The effect of dietary cholesterol is mainly seen only between 0-200 mg daily intake and further manifest only with simultaneous SFA intake. It is estimated that under certain conditions, every 100 mg cholesterol intake will raise total serum cholesterol by 12 mg%.

Simple carbohydrates raise triglycerides, again very significantly in the disease states. In fact, substitution of the simple carbohydrates by complex carbohydrates and an increase in dietary fibre, especially of soluble variety has been a very important health promoting maneuvre.

High triglyceride levels are common in obesity, diabetes and as a part of syndrome X. In fact, in Asian Indians, high triglyceride is a more common lipid abnormality than high LDL-cholesterol (Table1).

TABLE 1. LIPID PROFILE IN CORONARY ARTERY DISEASE

Parameter	Whites (mg /dl)	Indian (mg /dl)
TC	270	207
TG	175	193
HDL	47	36
LDL	189	124
Lp (a)	<30	>30

This anomaly is further associated with higher levels of dense, small LDL (Lp (a)) and low HDL-cholesterol (Miller et al. 1988). The last two anomalies are probably determined genetically, yet to a smaller extent modifiable by environmental manipulation. Overall, this makes a highly atherogenic lipid profile. In this setting, especially in the presence of impaired glucose tolerance, diabetes and obesity, lowering of triglyceride becomes an important objective. Replacement of dietary carbohydrate by monounsaturated fats has been shown to reduce triglycerides, as well as improve glycemic control (Garg et al. 1988).

Total Fat intake

Total fat intake has been firmly correlated to weight gain and development of Type 2 diabetes and coronary artery disease. Low fat diets have a great role in weight loss and weight maintenance programs. In this regard, recent interest in high-fat, high-protein diet of Atkins requires critical analysis (Samaha 2003). The positive feature of this diet is carbohydrate restriction, which maybe a very important maneuvre in Asian Indians. However, an indiscriminate increase in fat intake may be undesirable. Also, the fat intake should occur mainly in the form of kindly fats, like MUFA.

SFA, PUFA and MUFA

Literature abounds in the benefits and risks of using dietary fats of various chain lengths and saturation (Table 2). Saturated fats have been uniformly condemned, but score over all fats when high - temperature cooking is used, as they resist oxidation. They also have a better shelf life, another small advantage. Saturated fatty acids of < 12 carbon units do not raise cholesterol and stearic acid (C 18) does not raise cholesterol as it is converted to oleic acid by desaturation at C9-C10. SFA were replaced by PUFA, based on studies showing effective lowering of cholesterol and triglycerides by PUFA (Mata et al. 1992). Subsequently, effect of PUFA, especially the n-6 variety on oxidative stress and thrombogenic potential was brought out. Hence, PUFA of n-3 type were recommended. More importantly, an optimum ratio of n-6 to n-3 was recommended. Infact, there was some resurgence of interest in recommending SFA instead of PUFA for the reason that SFA (like ghee, butter) were low in n-6 fatty acids. Such vehement advocacy of ghee and butter intake attracted considerable media attention and many investigators, not realizing the basic harmful effects of SFA, sought publicity by recommending wide use of SFA.

TABLE 2. FATTY ACID COMPOSITION OF OILS

OIL	SFA %	MUFA %	PUFA %	ω-3 (PUFA %)
GROUNDNUT	19	52	26	Nil
SESAME OIL	14	45	40	Nil
SAFFLOWER	5	15	76	Nil
MUSTARD	9	64	14	9
COTTONSEED	25	24	48	Nil
SUNFLOWER	7	34	58	Nil
FLAXSEED	72	19	9	58 %
RICE BRAN	18	45	36	Nil
SOYABEAN	16	24	53	8
COCONUT	42	6	2	Nil
LINSEED	8	16	15	50
CORN	13	30	56	Nil
CANOLA	6	61	22	1

A balance of opinion was restored with the recognition of virtues of MUFA and ultimately an optimal ratio of SFA: MUFA: PUFA as 1:1:1 was suggested.

N-6 PUFA cause increased platelet aggregability, thromboxane production and increased PAI-1 and fibrinogen levels while n-3 PUFA have reverse effects. Fish intake was seen epidemiologically to be associated with lower prevalence of CAD (Mensink et al 2003, Ascherio et al 1996). There has been considerable confusion regarding the type of fish, but all types of fish, from fresh water or sea, if containing enough fat, have shown to be beneficial.

An attempt has been made to treat vegetarians by giving fish oil capsules. However, most long-term studies have not confirmed the benefits of fish oil supplementation, except one recently (Von Shacky, 1999). This study showed slower progression of atherosclerotic plaques, as seen angiographically, in fish oil treated subjects suffering from CAD as compared to controls. Although studies on the beneficial effect of n-3 fatty acids abound, it is important to point out that n-3 fatty acids may lower HDL-cholesterol while lowering LDL-cholesterol and in some studies it has been shown to even increase LDL-cholesterol. However, this increase in LDL-cholesterol is probably in the form of less dense and less atherogenic component. High intake of n-3 fatty acids can impair immunity by lowering prostaglandin E-2 levels, reducing CD-4 cells and mitogenic response. High intake of eicosapentanoic acid, a n-3 fatty acid is associated with the deterioration of metabolic control in diabetes.

A large body of scientific data extols virtues of MUFA. In a group of hypercholestrolemic subjects, low, moderate and high MUFA intake reduced LDL-cholesterol in a dose dependent manner. (Jason 2003). Replacing SFA by carbohydrates or omega –6 PUFA causes lowering of HDL-cholesterol, while this does not occur when SFA are replaced by MUFA.

A comparison of high SFA, high MUFA and low fat diets was made in hypercholestrolemic subjects. High MUFA diet reduced LDL-cholesterol by 21%, while low fat diet reduced LDL-cholesterol by 15%. Low fat diet was associated with high triglyceride and lower HDL-cholesterol, probably because of increased carbohydrate intake (Grundy 1986).

In Type 2 diabetes, a high carbohydrate diet (60% carbohydrate, 25% fat) has been compared to high fat (50% fat, mainly MUFA, 35% carbohydrate) diet. High MUFA diet was associated with improved metabolic control of diabetes and decreased insulin dosage. In addition, high MUFA diet reduced triglyceride levels and increased HDL-cholesterol. The LDL-cholesterol was not much altered by the high MUFA diet (Garg 1988).

In healthy adults, a high MUFA as well as high PUFA diet reduced total cholesterol, LDL-cholesterol, HDL-cholesterol, apoB and apoA. However apoA levels were higher in MUFA group as compared to PUFA group (Wahrburg 1992).

In a group of healthy pre and postmenopausal women, a comparison of SFA, MUFA and PUFA was made. Both MUFA and PUFA diets reduced LDL-cholesterol but HDL-cholesterol and apoA was higher in MUFA group as compared to PUFA group (Mata 1992).

In a group of healthy adults, a comparison of MUFA versus carbohydrate was made, keeping SFA and PUFA as constant. The MUFA diet decreased LDL-cholesterol as well as HDL-cholesterol and decreased oxidisability of LDL-cholesterol (Berry 1992).

A comparison of sunflower oil with oleate-enriched sunflower oil produced LDL, which was less susceptible to oxidation in oleate-rich oil. In a group of hypertensive subjects, MUFA and PUFA diets were compared. The resting BP was lower in the MUFA group, so much so that anti-hypertensive drugs could be omitted in about one-third of the patients in the MUFA groups. This beneficial effect on blood pressure was attributed to the polyphenols contained in the MUFA (extra virgin olive oil) (Ferrara 2000).

Fat consumption in a group of diabetics and non-diabetics (Table 3) reveal that SFA and PUFA were high whereas MUFA consumption was unusually low. Based upon the above, this requires correction by a massive public health education drive.

TABLE 3. PATTERN OF FAT CONSUMPTION

	Diabetics		Non Diabetics	
	Males (n=37)	Females (n=26)	Males (n=26)	Females (n=28)
Calories	2175 ± 673	1912 ± 568	2366 ± 864	1976 ± 6581
% Cals. from				
CHO	50 ±12	53 ± 12	51 ± 13	53 ± 19
Protein	12 ±4	12 ± 5	12 ± 4	13 ± 5
FAT	8 ±17	34 ±15	36 ± 15	34 ± 15
SFA	5 ± 8	12 ± 11	13 ± 8	13 ± 9
MUFA	5 ± 4	6 ± 4	5 ± 3	5 ± 3
PUFA	9 ±10	16 ±6	18 ± 8	17 ± 6

Low –Calorie Fats and Fat Replacers

There are various substances that can be used to replace fats in food and are known as fat replacers. Fat mimetics are those that mimic fats in their texture, feel, taste and substitute fats in the food. They may be carbohydrate or protein in nature. Carbohydrates as non-caloric fat mimetics contribute 2 Calories per gram. Examples are cellulose gel, cellulose gum, pectin, sugar gum, carageenan, xanthan gum, brans. They are mainly used in frozen desserts, yoghurt gravies, sour cream, dips, cheese spread, processed cheese, dairy products, and beverages. Carbohydrate as caloric fat mimetics is mainly maltodextrin, dextrin, modified foods, starch, polydextrose, oatrim, corn syrups. These are used in baked foods, meat products, frozen desserts, salad dressings, sauces, soups, cheese, candy, chewing gum, and confections. Protein as fat mimetics provides 4 Calories per gram. Usually micro-articulated egg white, milk protein, whey and zein are used in various products. Butter, cheese, mayonnaise, spreads; salad dressings utilize these proteins as fat replacers.

Low-calorie fats provide 5 Cal / gm as compared to the 9 Cal / gm of regular fat. The natural source for caprenin is palm kernel and coconut oil and salatrim is canola and soy. They are used widely in the food industry as a cocoa butter substitute, in candy coating, chips, crackers, and shortenings in baked goods. Both caprenin and salatrim are medium-chain triglycerides. Caprenin (mainly capric, caprelic, behenic acid esters), Salatrim (mainly acetic acid, propionic acid and butyric acid) are short–chain fatty acids whereas stearic acid is a long-chain fatty acid.

Fat substitutes contribute negligible Calories. Well-known examples are olestra, sorbestrin and esterified propoxylated glycerol. Olestra is a mixture of hecta, hepta and octa esters of fatty acids with sucrose. Sorbestrin is a hexaester of sorbitol. These are popularly used abroad (Chandalia and Modi 1999).

Sources of Dietary Fat

Visible and Invisible Fat: Dietary fat is mainly of two types, visible fat and invisible fat which is obtained from animal or plant sources. Animal sources are milk, meat, chicken; shellfish are rich in SFA and cholesterol, with the exception of some fatty fish, which are rich in omega–3 fatty acids. The plant sources are mainly cereals, pulses, millets, nuts, oilseeds, and green leafy vegetables. They are rich in linolenic acid and alpha–linolenic acid. Visible fat in the solid form are butter, ghee and hydrogenated vegetable oils like vanaspati whereas in the liquid form as oils are coconut, palm, peanut, sesame, olive, sunflower, safflower, corn, mustard, soyabean, ricebran, flaxseed oil.

Unprocessed Fats, Processed Fats and Partially hydrogenated Fats0

Unrefined oils have a low smoking point and are damaged on high temperature–prolonged heating. They have increased sensitivity to light and have a short shelf life. Unrefined oils preserve their antioxidant content mainly carotenoids and tocopherols. Appropriate packaging of these oils is important.

Refined oils are usually colourless, odourless, bland and neutral products. They have a high smoking point and are stable at high temperatures. Refined oils show reduced susceptibility to light and oxidation. The refining process strips the oils of their natural antioxidant content especially carotenoids and tocopherols. In some refined oils the linolenic and alpha-linolenic component may be destroyed due to lack of stability to light.

Partially hydrogenated fats are manufactured by the partial saturation of unsaturated fats so as to improve texture, taste and shelf life of the product. This process destroys the essential fatty acids and other nutrients. These fats are mainly found in products like margarine, shortening, commercial baked foods and processed foods. They also generate trans-fatty acids and free radicals, which contribute towards diabetes, cancer and cardiovascular disease. They are positively more harmful as compared to refined oils. Unfortunately, partially hydrogenated fats today are present so widely used in the food industry that it is difficult to avoid consumption. At present, food labels abroad do mention "no trans-fatty acid" to inform consumers. But they will be required to include more detailed information on the nutrition label from next year (Molseed 2004).

Trans-fatty acids and Cis-fatty acids

Trans-fatty acids are generated due to processing of the oils. They are an undesirable, modified form of the fatty acid, which do not fit into the integral, structural membrane of cells in the body. Hence, they are unstable, get oxidized and give rise to free radicals. This exerts a harmful effect by increasing their atherogenic potential (Allison et al. 1995).

On the other hand, cis–fatty acids are the natural and desirable form of dietary fat. They help in maintaining the structural integrity of body cells. They are highly stable and do not undergo peroxidation, hence are anti-atherogenic in nature (Passmore and Eastwood 1986).

Comparatively, nuts are a natural cis form of fat, which are calorie-dense foods, low in SFA but high in MUFA and PUFA. They contain essential fatty acids too e.g. Walnuts contain n-3 fatty acid. Coconut palm and avocado are an exception to the rule. Additionally, nuts also contain moderate quantity of protein, fibre, flavonoids, antioxidants, plant sterols and phytochemicals. They are infact a rich source of the right type of fat for vegetarians. They are a healthy natural alternative to high-fat processed foods. Nuts are known to be beneficial in decreasing total cholesterol.

Micronutrients in Oils

Dietary fats have other beneficial properties. They contain micronutrients like vitamin A, D, E, flavonoids, phytosterols, alpha-linolenic acid, alpha-linoleic acid and gamma-oryzanol. These micronutrients are beneficial in various diseases.

Toxins in Oils

Other properties of fats need consideration to make them fit for consumption as edible oils. The edible oil also has to be made free of toxins. Argemone mexicana, the prickly poppy plant contains alkaloids with active toxin sanguinarine. It causes 'epidemic dropsy'. In this condition an increase in the permeability of blood vessels especially in the heart, liver, and eye cause swelling of the entire body. Even a 1% adulteration by argemone oil can cause this condition. Hence, one has to ensure the quality of mustard oil and avoid filtered or unrefined and un-packaged mustard oil (Sarkar 1948).

Another toxin called erucic acid constitutes 45% of the total content of conventional rapeseed oil. It may damage the heart muscle by slow oxidation. After processing, erucic acid content reduces to 2%. Thus, processing of fat is beneficial to eliminate toxins in this instance (Abdellatif 1973).

A toxin called 'aflatoxin' is continuously found in peanuts, especially in humid conditions. This toxin is stable to heat in dry state. Destruction of the toxin is possible by heating at high temperatures e.g. roasting (Krishnamachari et al. 1975). This toxin has been known to produce hepatic carcinoma.

Cooking Properties of Fat

The cooking properties of fat are required to be understood as this decides their use for various purposes. The crucial characteristics for cooking oils are flavour, texture, smoke-point and price. The smoke-point of any oil is that temperature, at which the oil begins to smoke, discolors and decomposes. Beyond this smoke-point the food burns and produces an unpleasant taste.

Unrefined oils have a lower smoke-point than refined oils. Oils with higher smoke-point are ideal for cooking and frying. Oils with lower smoke-point can be used for sautéing for short periods. Unrefined oils need to be added at the end-cycle of cooking.

Unrefined oils like sesame seed, extra-virgin olive, peanut; soybean, corn, sunflower, safflower and flaxseed have a smoke-point between 225° F to 350° F. It can be used for stir-frying, sautéing, browning and deep-frying.

Refined hydrogenated butter, vegetable shortening, canola, peanut, sunflower, safflower, soybean, cottonseed have a smoke-point between 350° F to 520° F. They can be used for stir-frying, sautéing, browning and deep-frying.

Summary

The intake of dietary fat is poorly regulated in the body, thus warranting dietary fat guidelines for the population.

The relationship of dietary fat to health and disease has been well documented about half a century ago. Decade by decade every aspect of dietary fat has undergone scrutiny. Ultimately, the ADA set the recommendations for dietary fat intake in the eighties. A consumption of upto 30% of total calories from fat with an optimal proportion of 7% as SFA, 12-14% as MUFA and 6-8% as PUFA respectively. The role of n-6 and n-3 PUFA in cardiovascular disease has function was examined extensively. A critical review of dietary fat brought out the virtues of MUFA and n-3 fatty acids. Replacement of dietary carbohydrate with MUFA also elucidated its beneficial effect on TG and glycemic control in diabetes.

Fat replacers and low-calorie fats have been used to help cut down total fat intake and calories, thus helping in weight maintenance strategies. A long-term effect of such modifications in the diet is yet to be studied.

Other important considerations in the selection of dietary fats are cis or trans form, amounts of antioxidants and other beneficial micronutrients, cooking properties and the process of refining. Oil in natural form from nuts and other foods or unrefined filtered oil is desirable, but has shorter shelf life. Refined oils and saturated fats like ghee or butter have better shelf life and withstand high cooking temperatures.

Consumption of MUFA and n-3 PUFA in natural or unrefined form appears to be the best dietary fat at present.

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MUSTARD OIL

K. Sen Ray
Department of Food Science and Nutrition
SNDT Women's University, Mumbai – 400049

Mustard as spice and its oil has been used in food for thousands of years, in many countries. It has even been mentioned in ancient Sanskrit writings dating back about 5,000 years ago. The seed of mustard plant is a cruciferous vegetable. As it grows well in temperate climates, it is being used on a substantial scale on the Indian subcontinent, and in China and Russia for the production of cooking and salad oil. Mustard seed is one of the most economically important oilseed crops and the second most important group of oilseed crops in India after groundnut. This crop accounts for 27.5 % of the total oilseed production and 13 % of the gross cropped area in the country. Besides India, the areas that produce the greatest amount of mustard seeds currently include Hungary, Great Britain, Canada and the United States as a condiment for its hot-tasting and pungent-smelling compounds. Within India the consumption pattern of different oil seeds vary considerably, depending on the local crop production.

Mustard oil is widely known for its sharp nutty flavour. It is cold pressed from the whole seed, with no heat treatment, and is then filtered through cotton and paper, and bottled. The characteristic mustard flavour is developed in the presence of water through the action of the myrosinase enzyme system. The myrosinase enzyme system releases an isothiocyanate, which in turn creates the sharp flavour of mustard. There are two types of isothiocyanates found in mustard. The volatile type is found in brown and oriental mustard and a non-volatile type is found in yellow mustard. The flavour profile of mustard does not linger. Rather it presents itself quickly, dissipates, and leaves little or no after-taste.

There are approximately forty different varieties of mustard plants but there are three principal types commonly used - black mustard (Brassica nigra), white mustard (Brassica alba) and brown mustard (Brassica juncea). Black mustard seeds are the most pungent one. Mustard seed oil retains the characteristic colour, aroma and taste of the parent seed during processing and the hot elements (or the pungent taste) do not enter the oil during pressing. The oil contains no additives or preservatives.

Special attributes of Mustard oil:

- Indian mustard (Brassica juncea) occupies the largest acreage among all oleiferous brassicas grown in India. High oleic, moderate linoleic and low linolenic acid contents in the oil are considered beneficial for human consumption.
- Mustard does not contain antigrowth factors like those found in soybeans.
- Mustard is a popular crop in crop rotations, since it enhances yields and breaks disease cycles in cereal grains.
- Mustard is related to canola but has a lower susceptibility to shattering of ripe pods, important in harvesting a greater resistance to drought and water-logging and a greater resistance to certain diseases - notably blackleg - and insect pests.
- The oil of mustard seed is nutritionally similar to other oils and makes up 28% to 36% of the seed.
- Tocopherols present in mustard help to protect the oil from rancidity, thus contributing to a long shelf life.

- The oil obtained from presently cultivated varieties of Indian mustard is characterized by high amounts of erucic acid (40-50%), which is considered nutritionally undesirable.
- The essential oil in mustard inhibits growth of certain yeasts, molds, and bacteria enabling mustard to function as a natural preservative.
- Mustard oil is healthy as it has 30 per cent protein, calcium, phytins, phenolics and natural anti-oxidants.
- Glucosinolate, the pungent principle in mustard oil, has anti bacterial, anti fungal and anti-carcinogenic properties, which account for many medicinal utilities of the oil.
- Mustard oil contains high amount of mono-unsaturated fatty acids and a good amount of polyunsaturated fatty acids. It contains the least amount of saturated fatty acids, making it comparatively safer for heart patients.
- The effect of dietary mustard oil (containing omega 3-polyunsaturated fatty acid) on azoxymethane-induced colon cancer in rats has been found to be maximum as compared to corn and fish oil treated groups thus proving its chemo preventive effects.

Physical Characteristics

Mustard oil contains both the essential fatty acids, linoleic and linolenic, which are required for important metabolic functions in the body (Table 1). However, some anti-nutritional factors in the oil and oilcake have limited its use and export possibilities. The oil obtained from presently cultivated varieties of Indian mustard is characterized by high amounts of erucic acid (40-50%), which is considered nutritionally undesirable and low oleic acid (10-15%) attributing to low shelf life (Kaushik and Agnihotri 2000). Due to high level of monounsaturated fatty acid, mustard oil has demand in commercial food applications as it has long shelf life and cholesterol reducing property. Less than 3 % linolenic acid is preferred for the stability of the oil.

TABLE 1 CHEMICAL CHARACTERISTICS OF MUSTARD OIL

Parameter	White Mustard Seed oil	Black Mustard Seed oil
Saponification value	170-181	174-180
Refractive Index at 20*C	66 – 73	68-74
Iodine value	94 -112	96-114
Specific gravity,15.5/15.5*C	0.913-0.921	0.912-0.919
Free fatty acids, as Oleic, %	Up to 4	Up to 4
Unsaponifiable matter,%	0.7-1.5	0.7-1.5
Titre. *C	8-10	6-10

Source: Williams 1966

According to Indian Standard Institution (1963), only acid value and natural essential oil have been considered for its quality standardization. But low erucic acid is the requirement for good quality mustard oil though it has not been mentioned in the standard. Indian Standard Institution (1963) specification for Mustard oil for its standard quality is as follows:

Characteristics	Grade I	Grade II
Moisture and Insoluble impurities; % by wt . Max	0.25	0.25
Color in a ¼" cell on the Lovibond scale expressed in (y +5R), not deeper than	50	50
Refractive Index (40°C)	1.46 -3	1.46 - 3
Specific gravity (30/30°C)	0.907-1	0.907-1
Saponification value	170 – 176	170-176
Iodine Value (wij's)	98 -108	98 –108
Acid Value (max)	1.5	6.0
Unsap matter, % by wt (max)	1.2	1.2
Natural Essential oil % by wt (as alkyl isothiocyanate)	0.25-0.60	0.10–0.80

Quality of edible oil depends on fatty acid composition of vegetable oil. Rapeseed-mustard oil differ from most other vegetable oils in containing significant amount of long chain monoenoic acids with 20 and 22 carbon atoms called eicosenoic and erucic respectively. This erucic acid and glucosinolates have shown toxic effect on experimental animals. The original form of mustard seed contains both erucic acid and hot tasting glucinosolates but erucic acid gets extracted in the oil while majority of the hot-tasting glucinosolates are left in the meal after the oil is removed from the seed. Erucic acid has a degenerative effect on heart muscle if consumed in large amounts. Only less than two percent of erucic acid is preferred for daily consumption.

The use of Indian mustard oil is discouraged in the International market due to its high erucic acid and glucosinolate content. Western countries Including U.S. have banned the use of Indian mustard oil, which affects the export of this oil from India. To make mustard a useful modern crop, it is necessary to reduce the levels of erucic acid and glucosinolates. Tailor made designer rapeseed-mustard varities have already been developed in Europe, Canada and Australia (Downey et al.1969; Singh and Green 1999). But in India research on oil modification was only initiated during the late 1990s to develop gene pool with ideal fatty acid composition for human consumption. The research efforts during the late 1990s have led to the generation of some low erucic acid strains. But owing to a common biosynthetic pathway, the reduction in erucic acid also affects the composition of other fatty acids (Kaushik and Agnihotri 2003).

CSIRO Scientists are working to develop a new Indian mustard variety, which does not have pungent compounds in the seeds. This new type of mustard seeds are expected to have the benefits of nutritionally improved oil composition to meet modern health requirements of high oleic and linoleic acids in the oil, a favorable balance of mono and poly-unsaturates making it good for people prone to heart trouble.It can be seen that the fatty acid profile of cultivated varieties is not ideal for edible purposes. Among the newly developed quality lines, B.napus line TERI (OE) RO9 has the best fatty acid profile having high oleic, moderate linoleic and low linolenic acid contents, ideal for human nutrition (Table 2).

Epidemic dropsy is a clinical state resulting from use of edible oils adulterated with Argemone mexicana oil. Sanguinarine and dehydrosanguinarine are two major toxic alkaloids of Argemone oil, which cause widespread capillary dilatation, proliferation and increased capillary permeability. Leakage of the protein-rich plasma component into the extra cellular compartment leads to edema. The haemodynamic consequences of this vascular dilatation and permeability lead to a state of relative hypovolemia with a constant stimulus for fluid and salt conservation by the kidneys. Symptoms of dropsy are acute nausea, vomiting, loose motions, bloated stomach, erythema and swelling of hands and feet known as edema. In extreme cases, glaucoma and even deaths due to cardiac arrest have been reported (Sharma et al. 1999).

TABLE 2. FATTY ACID COMPOSITION (%) OF SELECTED B *JUNCEA* AND B. *NOPUS* LINES

Strain	Oleic acid (C18-1)	Linoleic (C 18-2)	Linolenic (C18-3)	Erucic (C 22-1)
B. *juncea*				
Pusa Bold*	12.70	20.20	20.00	51.00
Varuna*	14.60	11.20	8.10	48.50
Kranti*	17.50	15.80	9.50	48.00
Bj 2-6	43.50	35.40	14.60	0.00
Bj 3-9	42.98	35.32	14.67	0.00
Bj 5-5	45.84	45.84	13.32	0.00
PBCM178 וו	46.30	34.40	14.40	0.00
B. *napus*				
GSL – I*	21.60	14.80	20.50	36.70
ISN706*	23.11	18.08	22.75	29.81
TERI(00)R986†	48.00	32.70	12.90	0.00
Hyola 401וו	58.40	20.30	14.37	0.00

*cultivated variety †Developed at TERI

וו Available from All India Coordinated Research project on rapeseed and mustard.

Source: Kaushik and Agnihotri 2000.

Other than high erucic acid content, there is another health threat from mustered oil when adulterated with oil of prickly poppy that grows as a wild weed. Prickly poppy seeds are blackish brown in colour and have wrinkled surface while mustard seeds have a smooth round surface.The line of treatment in argemone-intoxicated epidemics has so far been only symptomatic. No specific therapeutic measures are established. It has been suggested that diuretic, bioantioxidants, steroids, vitamins, calcium and protein-rich diet have some beneficial effect on epidemic dropsy cases.

Contamination of mustard oil with argemone oil can easily be confirmed by a Ferric Chloride or thin layer chromatography method.Standards for mustard oil laid down under Indian Regulations has stipulated that it has to be free from argemone oil. During the epidemic, the Government banned sale of mustard oil in the affected states. Samples of mustard oil were obtained from different sources including retail and factory outlets, for testing. The media played an important role in educating the public. The government authorities carried out a campaign to further educate the public and offered door-to-door medical examination to detect and advise persons affected.

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RICE BRAN OIL

Subhadra K
College of Home Science, 49, New Marine Lines, Mumbai- 400.020.

The ever growing demand and soaring prices of edible oils can be controlled by tapping the sources of unconventional oils such as rice bran, mango kernel, tomato seeds, chilli seeds etc. which require no additional land for cultivation besides being cost effective. Rice bran oil (RBO) is extracted from rice bran, a by product formed from the outer layers of the husked rice kernel during the process of milling. It is a layer between husk and endosperm of the paddy grain. Rice bran contains 21-25% of oil. Several human and animal trials have proved the health effects of RBO. India is the prime producer of RBO (370,000 tonnes) followed by Japan (83,000 tonnes) and China including Taiwan (122,000 tonnes).

Chemical composition:

The crude RBO contains slightly higher amount of unsaponifiable matter (4-6%) than permitted (3%) by the Central Committee of Food Standard. But the modern technological processes such as refining, bleaching and deodourisation could make it possible to obtain tasteless and odourless oil. However, the unsaponifiable fraction of RBO has been found to contain several phytonutrients such as tocophenols and tocotrienols (72-612 ppm), phytosterols and gamma oryzanol (115-780 ppm), that are well known for their antioxidant properties (Indra Ravindranath 2002). Oryzanol is a mixture of compounds such as ferulic acid esters of campesterol, beta sitosterol and stigmasterol. The brown colour of crude RBO has been attruibuted to the methyl ferulate. Presence of squalene (an unsaturated hydrocarbon) in considerable amount (0.2-0.4%) is another special characteristic of this oil. Squalene, which is generally found in marine fish liver oils has been found to contribute the flavour characteristic of RBO (Indra Ravindranath 2002; Babcock 1987). Table 1 shows the various chemical properties of RBO.

TABLE 1 GENERAL CHARACTERISTICS OF RBO

Saponification value	180-212
Iodine value	90-105
Unsaponifiable matter	4.0-6.0
Refractive Index	1.469-1.470 (25°C)
Specific Gravity	0.916-0.921(25°C)
Smoke Point	415°F

Source: Indra (2002), Babcock (1987)

There was 20% less oil absorption in the food products deep-fried in RBO, which was attributed to the viscosity and other physical characteristics of the oil. Isomerisation and polymerization of the fatty acids, and the generation of free radicals at high temperatures are associated with the low smoke point of some of the edible oils. But the high smoke point of RBO prevents these undesirable changes in it on heating.

RBO has a fatty acid composition similar to that of groundnut oil (Table 2) with an ideal fatty acid profile as suggested by the American Heart Association (SFA≤10%, MUFA≥10% and PUFA=10% 0f the dietary fat). The various nutritional and therapeutic benefits of RBO have been attributed either to the ideal fatty acid profile or to the unsaponifiable matter of RBO. The major unsaturated fatty acids in RBO are oleic acid and linoleic acid.

TABLE 2. CHEMICAL COMPOSITION OF RBO

Fatty acid	Amount (mg %)
Unsaturates	
Oleic acid	38.4
Linoleic acid	34.4
Linolenic acid	2.2
Saturates	16-20
Myristic acid	0.1-1.0
Palmitic acid	21.5
Stearic acid	2.9
Unsaponifiable fraction	4.2
Total Tocopherol	81.3
Gamma oryzanol	1.6
Cycloartenol	106
24-methylene cycloartenol	494
Squalene	320

Source: Rukmini, Raghuram (1991)

Toxicological studies conducted at NIN had proved the safety of RBO for consumption. It was also reported that neither RBO nor the foods deep-fried in it showed any mutagenecity as judged by Ames test. RBO was not found to affect the reproductive performance in animals. A safety evaluation carried out by the FDA/WHO protocol also proved that RBO is safe for consumption.

Therapeutic benefits of RBO:

The beneficial role of RBO in hypercholesterolaemia and Hyperlipidaemia has been proved by several human and animal studies. Lichtenstein (1994) compared the hypolipidaemic effect of RBO with that of canola, corn and olive oils and reported that the lipid lowering effect of RBO was similar to the other oils and better than that of olive oil in moderately hypercholesterolemic humans. A significant reduction in the serum lipids (triglycerides, LDL, VLDL & TC) and lipid peroxides was reported in healthy humans on RBO supplementation (Rajnarayana et al. 2001). Cicero and Gaddi (2001) studied the effect of RBO and gamma oryzanol on hyperlipoproteinaemias and other conditions and found that RBO and its component gamma oryzanol were effective in reducing the total plasma cholesterol and triglyceride concentrations and increasing the high density lipoprotein cholesterol levels in animals as well as humans. The non fatty acid components (unsaponifiables) of RBO were found to be responsible significantly to its cholesterol lowering capacity (Wilson et al. 2000). A 5% reduction in serum total cholesterol and 9% reduction in LDL cholesterol were observed by Vissers et al. (2000) with the supplementation of 2.1g plant sterol from RBO in normolipidaemic humans. This effect has been attributed to ss-sitosterol and other 4-desmethylsterols but not to 4,4'-dimethylsterols. A similar finding has been documented earlier by Rukmini and Raghuram (1991) where supplementation of cycloartenol and 24-methylene cycloartenol (CA) in amounts present in RBO to hypercholesterolemic rats for 8 weeks was found to reduce total cholesterol and triglycerides significantly. An increased excretion of endogenous cholesterol was found in animals given CA. The lipid lowering effect has been attributed to the inhibition of hepatic cholesterol esterase activity by the CA accumulated in the liver. The lipid lowering mechanism of CA was further explained. The structural similarity between CA and cholesterol, which might compete with cholesterol for binding sites resulting in the sequestration and thereby metabolic degradation of cholesterol. Seetharamaiah and Chandrasekhara (1989) also reported more significant lipid lowering effect of refined RBO in rats as compared to groundnut oil that has further reduced significantly on the addition of oryzanol to the diets. There was also a slight increase in HDL cholesterol in RBO fed animals. Gamma oryzanol was found to have the property of modulation of pitutory secretion, antioxidant action and inhibition of platelet aggregation (Cicero and Gaddi, 2001)

The unsaponifiable fraction of RBO is rich in various antioxidants such as tocopherols and tocotrienols. Inhibition of HMG CoA reductase, (a rate limiting enzyme in cholesterol biosynthesis) by tocotrienols might result in hypocholesterolaemia and also improved oxidative stability in the body. A significant reduction in the lipid peroxides, triglycerides, LDL, VLDL and total cholesterol in healthy human subjects was reported by Rajnarayana, and Krishna (2001) on consumption of 75 ml of RBO thrice a day in breakfast, lunch and dinner for a period of 50 days. The effect was reported to be due to the antioxidant and antillipidaemic effect of RBO. The antioxidant property of RBO was found to be useful not only therapeutically but also technologically in the preservation of foods such as milk powder (Nanua et al. 2000).

Meciadonol [O-methyl -3 (+)-catechin], a component of RBO was found to inhibit peptic acid secretion and its concentration in the pylorus ligation model and thereby reduce incidence, numbers and areas of ulceration, and protect mast cells against degranulation to preserve a normal vascular integrity. Thus consumption of RBO may be useful in the treatment of peptic ulcers in humans (Jayaraj et al. 1988). Ferulic acid, a phytochemical antioxidant found in RBO might be useful a chemo preventive agent (Taniguchi et al. 1999).

Search for edible oil with ideal composition has resulted in the concept of blending of oils. Composition of the resultant oil blend is expected to exhibit more therapeutic benefits than the individual constituent oils. Several observations were made on the blending of RBO with other oils such as safflower oil, sunflower oil etc. Sugano and Tsujii (1995 and 1996) found magnified hypocholesterolemic effect of RBO upon its blending with safflower oil in 7:3 (wt/wt). A combination of RBO and sunflower oil was not found to be satisfactorily hypolipidaemic by Sugano et al. (1997), which might be due to the difference in the triglyceride structure of safflower oil and sunflower oil. A similar beneficial effect has been reported by Koba et al. (2000) in a human trial. In another trial on the hypolipidaemic effect of blends of RBO with PUFA rich vegetable oils such as safflower oil and sunflower oil (7:3 wt/wt), Sunita et al. (1997) found an improvement in the lipid profile of rats fed on the blend for 28 days. An increased faecal excretion of cholesterol, decreased levels of TC, TG, LDL-C and increased levels of HDL-C proved the advantage of blending the oils. The antioxidants in RBO might also protect the PUFA rich oils used in blending from oxidative spoilage.

In addition to the above-mentioned therapeutic benefits, RBO was also found to decrease bone mineral loss caused due to hormonal imbalances in postmenopausal women.

Thus it may be concluded that among the various unconventional oils, RBO is one of the most potential health oils that could be consumed for prevention as well as curation of the most commonly occurring degenerative diseases such as CVD, Hyperlipidaemia, cancer etc.

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SESAME SEED OIL

Priyadarshini Muley
Research Asst. Coordinator, Sneha-MRC, Mumbai – 51.

Sesame is a member of the *Pedaliaceae* family. The name sesame (Til) is derived from Middle English sisame and from the Latin *sesamum*. SAME Family. Sesame (*Sesamum indicum*) has early origins in East Africa and in India (Nayar, Mehra 1970). It has been mentioned in early Hindu legends in which sesame seeds are said to represent a symbol of immortality. In the Asian mythology, it is told that God drank sesame wine the night before He created the world. Sesamum indicum (Indian sesame) is a genus of sesame self-growing in the west India. Its utilization by Man dates back to 3000 B.C. It is perhaps one of the oldest crops cultivated by man, having been grown in the near east and Africa for over 5,000 years for cooking and medicinal needs. The ancients attributed near-mystical powers to sesame. The oil was used in barter since it would preserve and store in the desert for years.

Over 5000 years ago, the Chinese were using sesame oil as a candle and for centuries they have burned the oil to make soot for the finest Chinese ink blocks. Sesame seeds are identified as the oldest condiment known to man dating back to as early as 1600 BC. Before the time of Moses, the Egyptians used the oil for lamp. It is also accepted that sesame seed was added as a flavour into food, and was the very first seed used for extracting oil. They are highly valued for their oil for its exceptionally resistant nature against rancidity. "Open sesame," the famous phrase from the Arabian Nights reflects the distinguishing feature of the sesame seedpod, which bursts open when it reaches maturity.

English *gingelly* and Portuguese *gergelim* (common in Brazil only) have their origin in the early colonial period. Arabic *juljulan* "sesame", which allegedly derives from an Arabic term meaning "ring a bell" referring to the sound of ripe seeds within the capsules. There are a few Indian names, e.g., Hindi *gingli* or *tilseed* from Hindi *til*. The words susam in Turkish, sesame in English, simsim in Arabic, semsem in Afro-Asian language family, sesamum in Latin and sesame in Greek all date back to semsent in the ancient Egyptian, ultimately to shaman shammi in Akkadian. African slaves, called benne seeds at that time, took sesame to America. Today in some regions of the USA and Mexico, it is still called benne seeds, which are small and pearly white. In a short time, it became an indispensable flavor for food, especially in South America. Today it is available everywhere, from Central America to Asia and North Africa. Sesame seed was also used as food and cooking oil for ages. Today it is still the basic cooking oil in the Near East and Far East.

Sesame oil is traded in any of the forms described above: Refined sesame oil is very common in Europe and the USA; most margarine is made therefrom. Cold-pressed sesame oil is available in Western health shops. In most Asian countries, different kinds of hot-pressed sesame oil are preferred. For example, a hot-pressed sesame oil is the preferred cooking medium in Southwest India (mainly, the union state Maharashtra) and Burma. A speciality particular worth noting is oriental (dark) sesame oil, which is obtained by toasting the seeds before pressing. Dark sesame oil is a common flavouring in Korea and in the Chinese province Sichuan, where it is used drop by drop as a condiment, e.g., for Sichuan hot and sour soup (*suanla tang*). Dark sesame oil is not suitable as a frying medium, unless it is diluted with bland oil. For example, Japanese *tempura* is made by deep-frying battered vegetables in a mixture of one part sesame oil and ten parts some other vegetable oil.

Today, world production is estimated to be spread over 15 million acres (6.2 million hectares) and over 57 % of the world production is in Asia (Table 1). Most of the Asian production is in India, China, and Burma (Myanmar). In Asia most sesame is consumed within 100 miles of where it is grown since farmers grow very small plots for their extended families. Africa grows 15 % of the world's sesame, with Sudan, Uganda, and Nigeria being key producers. However, political unrest in that area limits exports to the U.S. Latin America grows 4% of the total world production in Mexico, Guatemala, and Venezuela. The United States usually imports about 40,000 metric tons annually, mostly from Guatemala, Mexico, and India. The largest part of the market is the Far East, dominated by the huge Japanese demand for sesame seed oil used for cooking. Presently U.S. production is in an area of about 40,000 acres and is based primarily in Texas and Oklahoma; production practices have been described for the region.

TABLE 1 WORLD SESAME PRODUCTION IN 1999

Region/Country	Production[1]	
	(Hectares)	(Metric Tons)
Asia		
India	2,000,000	650,000
China	675,700	550,400
Burma (Myanmar)	500,000	186,300
% of total	**51%**	**57%**
Africa		
Sudan	1,450,000	220,000
Uganda	186,000	93,000
Nigeria	155,000	60,000
% of total	**29%**	**15%**
Latin America		
Mexico	58,000	32,700
Guatemala	50,000	34,200
Venezuela	46,000	23,500
% of total	2%	4%
World		
50 other countries	1,107,000	282,6000
Totals	6,228,000	2,427,000

[1] Source: FAO Production Yearbook 1987.

Physical and chemical characteristics

Sesame oil is mostly composed of triglycerides with unsaturated oleic acid (40 %), linoleic acid (45 %) and linolenic acid just about 1 %, besides about 13-15 % saturated fats (palmitic 7-12 % and stearic 3-6 %. Because of its powerful antioxidant property and because triply unsaturated fatty acids are missing, sesame oil has an excellent shelf life (Brar and Ahuja 1979).

Oriental sesame oil owes its characteristic flavour to a huge number of compounds which form only during the toasting procedure. Most prominent one is 2-furylmethanthiol, which also plays an important part in the flavour of coffee and roasted meat. Guajacol (2-methoxyphenol), phenylethanthiol and furanol (4-hydroxy-2,5-dimethyl-3(2*H*)furanone), vinylguacol, 2-pentylpyridine and other N-containing heterocycles are also reported. Other sources claim that pyrazines are the key aroma compoundso of toasted sesame seeds. It was found that pyrazines dominate tha flavour for mild roasing conditions (160 °C), while roasting at higher temperature (200 °C) leads to increased formation of furanes.

It contains 58 - 60 % fat and can be used as a laxative. Although it contains no cholesterol, 50 % of its oil content is unsaturated. As a precaution, it must not be consumed in high amounts. It is interesting to note that when sesame is used as a flavor, only a fraction of its oil content gets transferred to the food. A number of scientific researches proved that sesamin, crystalline cyclic ether found in sesame seed oil only, provides an antioxidant effect that prevents the absorption of cholesterol. Ancient people had stressed that women should eat a spoonful of sesame seed every day after chewing it well to regulate their menstrual cycle. The oil also contains monounsaturated fatty acids. The oil is stable and highly resistant to oxidation (rancidity), due to the presence of sesamin, a lignan, which is a natural preservative, stabilizer, and antioxidant.

Therapeutic uses

The rich, almost odorless oil expressed from the tiny seeds is very stable and contains an antioxidant system comprising sesamol and sesamolinol formed from sesamolin, which substantially reduce its oxidation rate. If properly stored, sesame oil is not likely to go rancid, making it popular as cooking oil in India and China (Price and Smith 1999). It contains linoleic acid and alpha linoleic acid as well as lecithin, and this may explain its benefit to the brain and nervous system. Like olive oil, sesame oil is considered good for lowering LDL cholesterol levels. White seeds produce the most oil, but in India it is believed that the best oil for healing is extracted from black sesame seeds (Patniak 1993). People with high "Vata" can be prone to anxiety, nerve and bone disorders, poor circulation, and lowered immunity and bowel problems such as wind, constipation and irritable bowel. Used regularly, sesame oil is wonderful for reducing stress and tension, nourishing the nervous system and preventing nervous disorders, relieving fatigue and insomnia, and promoting strength and vitality. Those patients who use sesame oil daily have reported feeling stronger, more resilient to stress, with increased energy and better resistance to infection. Its relaxing properties ease pain and muscle spasm, such as sciatica, dysmenorrhoea, colic, backache and joint pain. The antioxidants explain its reputation for slowing the ageing process and increasing longevity. It also lubricates the body internally, particularly the joints and bowels, and eases symptoms of dryness such as irritating coughs, cracking joints and hard stools. Research into the healing effect of applying sesame oil is beginning to emerge.

Sesame oil has antibacterial and anti-inflammatory effects. It stimulates antibody production and enhances immunity. It also has anti-cancer properties and has been shown to inhibit the growth of malignant melanoma (Sharma and Clark 1998). Til oil promotes growth, strengthens the memory, acts as an antitoxin. It also helps against burning sensations and promotes lactation in nursing mothers.

Variants in biosynthetic pathways resulting in altered fatty acid profiles of triglycerides in oil have been produced via tissue culture in sunflower and rapeseed (Ram et al. 1988). Similar fatty acid changes can be expected in sesame through somaclonal variation or direct gene introduction for specific biochemical modifications. Increased amounts of oleic acid, long-chain fatty acids and antioxidants should enhance the attractiveness of sesame for specialty chemical markets (Ram et al 1990).

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OLIVE OIL

G. Subbulakshmi
Research Unit, College of Home Science, Nirmala Niketan, Mumbai 400.020.

The Greek olive trees date back to 37,000 B.C and are hardy with fossilized leaves. In North Africa, since 12,000 BC and in the Sahara since Villafranchian stage Olea europaea L. has been known (Camps-Fabrer 1996). In the books of Old Testament such as Deuteronomy, Jeremiah, Hosea and Joel olives groves have been found to be mentioned and the oil was considered to be a healthy one according to the books of Kings, Chronicles and the prophet Ezekiel. Olive oil was Crete's most important export. In the nineteenth century, olive cultivation was on the expansion side, a process that began in the previous century (Ruiz 1996).

A tree can live from one hundred to thousands of years with or without producing oils at the later stage. The Egyptians, Hebrews, Greeks and Romans revere the olive tree for millenniums for its fruit with a multitude of uses. Nowadays, Americans are rediscovering olive oil as a delicious and nutritious addition to their diets. Olive oil has been cultivated and consumed in the Mediterranean countries for thousands of years. It had become an essential ingredient in Italian, Spanish, and Greek recipes, not only for its exquisite flavour but also for its health benefits.

In terms of production, Europe comes first with about 80 %, followed by Africa (11%), Asia (8.6 %) and South America 0.8 % (Fedeli 1996).

The Oleaseae family contains 20 – 29 genera according to the classification system (Morettini 1972). Different systems have been used in the classification of Olea europaea. Originally it was divided into two major groups. O.europaea var.sylvestris and O. oleopaea var. sativa. The first included all types designated as wild olives and the second all domesticated olives.

According to FAO (1984) Greece has the highest per capita consumption (60 g/d) followed by Italy (30 g /d) and Spain (25 g/d). The low incidence of coronary disease in Greece could be due to the extensive consumption of olive oil. The per capita consumption of olive oil per year is found to be 2.5 Kg. as per a 30-year study. It appears that the migrant elderly Greeks have substituted their olive oil consumption with other vegetable oils (4 g /d). The oil content of olive is only around 20 % as against the same in nuts and oilseeds. The process of extraction of oil involves crushing the fruit and separating the oil. The oil can be separated 1. by pressing the pomace and the oily must, followed by separation of the vegetable water and oil. This traditional system uses centrifugation at the second phase. 2. different surface tensions can be used for separation of the oil. 3. if the paste is mixed with oil, centrifugation followed by separation of the vegetable water and the pomace.

Though the terms such as "cold pressed", "first pressed", "and expelled pressed" and "mechanically pressed" are all used in the extraction of oil there is no difference between them as very little heat is applied while processing. Some cold pressed oils could be the third or fourth pressing, refined with heat and chemicals, affect the nutrients and rich fruity taste. The mature fruits are harvested resulting in a creamy, buttery flavoured extra virgin olive oil. In addition, the manufacturing process uses a dual-phase and tri-phase decanter for extracting olive oil, where no warm water is added.

The first pressing yields the best oil as no heat is applied but just mechanically pressed. This is termed as Extra Virgin oil and has low acidity. Virgin oil though comes from the first pressing may have undergone heating. Regular Olive oil is a blend of Virgin and refined oils. The addition of Virgin oil protects the lower grade oils from rancidity. The latest grade in the market is Light olive oil which has similar fat content to other grades but has a milder and neutral taste as it is further deodorised and bleached.

Physico-chemical characteristics of olive oil

The physical properties of oil that are not defined in terms of origin, acid composition and degree of processing are: The refractive index at 25^{0}C varies from 1.4665 to 1.4688 depending on quality with no major differences. The acid value ranges from 152 to 220, the saponification value from147 to 209 (non-saponifiable content varies from 1.5 to 3,0 depending on the methods of extraction) while the iodine value ranges from 0 to 274 depending on the acid composition (Fideli 1996).

The chemical composition depends to some extent on soil and climatic conditions (Fedeli, Cortesi 1993) refining method (Fedeli et al. 1971) and the area of production (Paganuzzi 1974). The oleic, palmitic, linoleïc, stearic and palmitoleic acids are the principal fatty acids while linolenic, arachic, behenic, lignoceric and eicosenoic acids occur in smaller quantities to form the triglycerides of olive oil. The saponifiable fraction (triglycerides) constitutes 99 % of the oil. 63 – 83 % of the oil is comprised of monounsaturated fatty acids (omega 9 oleic), followed by saturated fatty acids – palmitic 7 – 17 %and stearic – 1.5 - 5 % and palmitoleic 0.3 to 3.0 % and polyunsaturated fatty acids omega 6 linoleic 3 – 14 % and omega 3 linolenic <1.5 %. According to Fedeli and Testolin (1991) 2 – 3 tablespoons of olive oil can supply the daily requirement of 1 – 2 % of linoleic acid and 0.2 – 0.6 % of linolenic acid of the total energy intake.

The antioxidants and non-nutrients are found in large quantity in virgin grade (Yoo et al.1988 ; Cortesi , Fedeli 1983). Vitamin E (15 – 17 mg / 100 ml) 90 % of which are in the most biologically active alpha form. Acts as an antioxidant. Phenolic compounds like phenols, phenolics acids, poly phenols have antioxidant activity. Phytoestrogens exhibit both oestrogen and anti-oestrogen activity.

Sterols are an essential component of cell membranes, and both animals and plants produce them. The sterol ring is a common feature of all sterols; the differences are in the side chain. Cholesterol is exclusively an animal sterol. Over 40 phytosterols have been identified so far. The amount of total sterols in extra virgin olive oil found by different groups varies between 113-265 mg/100g oil (5;6). Two factors influencing this amount are the cultivars and the degree of ripeness of the olives (Gutierrez et al. 1999). By far the major sterol in olive oil is ß-sitosterol, mounting up to 90-95% of total sterols (Gutierrez et al. 1999, Kiritsakis, Markakis, 1987). Campesterol and stigmasterol make up for about 3% and 1%, respectively (Gutierrez et al. 1999, Kiritsakis and Markakis, 1987). Stanols are saturated sterols, which are virtually absent from typical diets (Jones et al. 1997).

Nutritional and therapeutic value

There are several reports on anti-tumor effects of phytosterols, especially ß-sitosterol. Von Holtz and colleagues observed that compared with cholesterol-treated controls, human prostate cancer cells treated with ß-sitosterol decreased their growth by 24% and induced apoptosis 4-fold (Van Holtz et al.1998). Furthermore, b-sitosterol was shown to nullify the effect of a carcinogen on the colon in rats (Raicht et al. 1980). Though, there is a need for more data on humans, it is convincing that phytosterols, and particularly ß-sitosterol, exerts distinct anti-carcinogenic effects in cancers of prostate, colon, breast and stomach.

The major hydrocarbon in olive oil is squalene, a triterpene and intermediate of the cholesterol biosynthesis pathway. Extra virgin olive oil contains squalene in an amount of about 400-450 mg/100g, while refined olive oil contains about 25% less (Owen et al. 2000). Some reports show squalene levels to be around 200-700 mg/100g in extra virgin olive oil (Smith 2000). According to the latter study, the average intake of squalene is 30 mg per day in the USA. However, with a high consumption of extra virgin olive oil, the intake can reach 200-400 mg per day as observed in Mediterranean countries (Smith, 2000). Individuals might even consume up to 1g of squalene per day with their diets, according to Gylling and Miettinen (1995), which is contradictory to the squalene cholesterol association shown by Miettinen and Vanhanen (1994) and Chan et al. (1996).

Squalene (0.15 mg / 100 ml) can inhibit cholesterol synthesis via the enzyme L – CAT. Evidence suggests that 60 to 80 percent of dietary squalene is absorbed from an oral dose and a substantial amount of dietary squalene is indeed converted to cholesterol in humans. However, this increase in cholesterol synthesis is not associated with consistent increases in serum cholesterol levels, possibly as a result of a concomitant increase in faecal elimination (Strandberg 1990). Although Miettinen and Vanhanen (1994) observed an increase in serum total and LDL-cholesterol levels after a dietary supplementation of 1g of squalene per day, the same could be normalized with a lower dose of 0.5g per day. (Chan et al 1996). Interestingly, when squalene was added to a protocol with low-dose pravastatin, the efficacy of pravastatin as a cholesterol-lowering drug was enhanced.

Kohno and colleagues (1995) observed that squalene is a highly potent quencher of reactive singlet oxygen on the human skin surface. In animal models, squalene also appears to play an important role in the health of the eye, especially the rod photoreceptor cells of the retina (Fiesler and Keller, 1997).

In addition to squalene, other hydrocarbons are also present, e.g. the pro-vitamin A ß-carotene, albeit in very small quantities (ß-carotene: 0.03 - 0.36 mg/100g) (Kiritsakis and Markakis, 1987). Cyclo-arthenol assists fecal excretion of cholesterol through increased bile acid secretion. Carotenoids and chlorophyll have antioxidant activity. Aromatic substances: Provide the characteristic aroma and taste of olive oil.

The beneficial health effects of olive oil are due to both its high (76 %) monounsaturated fatty acids mainly oleic acid as well as its high content of antioxidative substances which reduces the LDL cholesterol levels while raising HDL levels (Keys et al. 1990; Willet, 1990 and World health Organization, 1990). It does not upset the critical ratio of omega 6 to omega 3. A consumption of 25 ml of virgin olive oil per day for just 1 week brought down the oxidation of LDL cholesterol and raised the levels of antioxidant compounds, particularly phenols, in the blood (Anonymous, 2002).

Inclusion of olive oil in the diet may also prevent colon cancer as the Spanish study (Anonymous, 2002) showed that rats fed diet supplemented with olive oil had a lower risk of colon cancer than those fed safflower oil-supplemented diets. In fact, the rats that received olive oil had colon cancer rates almost as low as those fed fish oil. A very high concentration of the antioxidants vitamin A and vitamin E in olive oil are capable of neutralizing cancer-causing free radicals in humans.

It is widely believed that antioxidant substances such as vitamins E, K and polyphenols found in olive oil provide a defense mechanism that delays aging and prevents carcinogenesis, atherosclerosis, liver disorders, gastritis, ulcers, constipation and inflammations. Extensive researches on its therapeutic effects have shown olive oil to promote digestion, stimulate metabolism, and lower cholesterol levels.

As a cholagogue, it activates the secretion of pancreatic hormones and bile thus lowers the incidence of cholelithiasis (gallstone formation). In bone calcification problems this oil is helpful due to its oleate contents. Also helps on brain and nervous system development as well as overall growth while shielding the body against infection and healing the tissues, internal or external. The active vitamin E, linoleic acid and alpha linolenic acid, protect the human brain from ageing processes and toxic, immunological and viral attacks. The oléic acid in olive oil reduces blood viscosity thus prevents thrombosis. Interestingly, oleic acid is a medicine used to fight a rare degenerative disease known as ALD (Adrenoleukodystrophy), which occurs when a build-up of very long-chain fatty acids (C22 to C28) destroy the white matter (myelin) in the brain. Made with twenty percent erucic acid and eighty percent oleic acid, the medicine is called "Lorenzo's Oil", named after a boy with this condition.

There is a strong belief that olive oil is not fattening (Wahlquist et al. 1991, Kouris et al. 1991).

The oil has a high smoking point (235^0 C) thus is fairly stable even at high frying temperatures. Because of its high antioxidant content and oleic acid content the oil is less vulnerable to oxidation and subsequent formation of toxic products like peroxides and polymers. It has also been shown that olive oil does not penetrate the food but remains on the surface.

The oil needs to be stored in a cool, dark cabinet, not on the counter, or next to a stove, as both heat and light alter its nutritional value.

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FLAX SEED OIL

Naik Mridula
California, USA.

Flaxseed (Linum usitatissimum) or Linseed oil is an ancient crop used both as source of fiber and food. Flax remnants were found in Stone Age dwellings in Switzerland and ancient Egyptians made fine linens from flax fiber. Flaxseed oil is traditionally used in Egyptian cuisine in) *ful medames,'* a stewed (faba) bean dish served with garlic, onions, and cumin (Cunnane, 1995). Krutch (1965) believed that flaxseed was first used as a food before early civilizations discovered ways to convert its fibers into cloth and that one of the first domestic arts was the weaving of linen. The first century Greek physician Dioscorides lauded flaxseed's power for "mollifying all inflammation inwardly and outwardly."

The terms "flaxseed" and "linseed" are often used interchangeably although North Americans use "flaxseed" to describe flax when it is eaten by humans and "linseed" to describe flax when it is used for industrial purposes, such as linoleum flooring. In Europe, the term "flaxseed" describes the varieties grown for making linen. Flax varieties grown for human consumption are different from flax varieties grown to produce fiber for making linen (BeMiller et al, 1993).

Flaxseed oil or linseed oil derived from the seeds of the plant *Linium usitatissimum* has a deep yellow color. Flax oil produced by mechanical extraction employs cracking the seeds, flaking them between rollers, and pressing them in expellers. This pressing is done under intense pressure, and raises the temperature of the oil to 185 to 200°F (85–93.3°C). Typically, seeds are heated up to 250°F (120°C) before being placed in the expeller; heating makes the pressing more efficient. 'Cold-pressed' is a term typically used to describe oil that was extracted without using additional external heat.. This process limits the maximum temperature during processing to 35°C (Oomah, 2003).

Flax seeds range in color from medium, reddish-brown to a light yellow (Freeman, 1995). Seed color is determined by the amount of pigment in the outer seed coat – the more pigment, the darker the seed. Seed color is easily modified through simple plant breeding techniques. Brown-seeded flax, which is rich in alpha-linolenic acid (ALA), an omega-3 fatty acid, is the most common flax grown in Canada. Yellow seeded flax is one of two types. One type, a U.S.-developed variety named Omega, is as rich in ALA as brown flax. The second is an entirely different flax called solin, which is low in ALA. Solin was developed for the cooking oil market. While brown and Omega flax are sold in health food stores and over the Internet, solin varieties are not sold directly to consumers. In Canada, solin is required to have a yellow seed coat to make it easier for growers and handlers to keep it apart from brown flax seeds at all stages of handling.

Flaxseed constitutes one of the 10 major oilseeds in world. (Soybeans, cottonseed, canola/rapeseed, peanuts, sunflower seed, palm kernels, coconut, sesame seed, flax seed, and castor seed). According to Agriculture and Agri-Food Canada Bulletin, flaxseed production, at 2.1 Million tonnes (Mt), represents only 0.6% of the 320.5 Mt production of the ten major (Gower, 2002). World production of flaxseed has ranged between 2 and 3 Mt since at least 1935. Over the past few years, since the recent peak of 2.8 Mt in 1999-2000, there has been a marked decrease in production, due primarily to policy changes in Europe and decreased yields in

Canada. Canada is the largest producer of flaxseed in the world, with a 35% production share. Other major producers include China, the United States (US) and India, but of these, only the US has an exportable surplus of flaxseed. Argentina, once a large producer of flaxseed, is no longer a major player. Within Europe, the main producers of flaxseed are Germany, the United Kingdom and France.

World trade in flaxseed was estimated at 774,000 t for 2001-2002, about 2% lower than in 2000-2001. Canada is the dominant exporter, with about 80% of the world's exports. The main import markets are Belgium-Luxembourg, Germany, the Netherlands, and to a lesser extent the US and Japan. In the EU, policy changes have led to a decrease in the local production of flaxseed, and as a result, the EU relies on imports from Canada and the US (Gower, 2002).

The composition of flax can vary with genetics, growing environment, seed processing and method of analysis (Daun et al, 2003). Flaxseed contains fixed oil (30–45%)- triglycerides of linolenic, linoleic, oleic, stearic, palmitic, and myristic acids (Bruneton, 1995, Budavari, 1996). The oil content of flax can also be altered through traditional plant breeding methods, and it is affected by geography – the cool nights of northern Canada improve oil content and quality. The protein content of the seed decreases as the oil content increases (Daun and DeClerque, 1994).

Flax oil contains a mixture of fatty acids. It is rich in polyunsaturated fatty acids, particularly alpha-linolenic acid (ALA or LNA), the essential omega-3 fatty acid, and linoleic acid (LA), the essential omega-6 fatty acid. ALA present in flaxseed oil is in the form of a triglyceride and ranges from approximately 40 to 60 %. ALA. Lower amounts of linoleic acid and oleic acid (each about 15%) are also present in flaxseed oil. In addition, flaxseed oil contains varying amounts of the lignan, secoisolariciresinol diglycoside (SDG).

ALA constitutes 57% of the total fatty acids in flax, making it the richest source of ALA in the North American diet. Linoleic acid constitutes 16 % of total fatty acids. Flax oil and canola oil have the lowest levels of the nutritionally undesirable saturated fatty acids. The level of the desirable monounsaturates in flax oil is modest. Solin oil is low in the essential omega-3 fatty acid, ALA. Solin oil was developed by plant breeders in Australia and Canada, who modified traditional flax oil to reduce the ALA content from 50– 60% to less than 5%. Solin oil has a fatty acid profile that is similar to sunflower seed oil; making it a good choice for certain food applications like margarine (Green and Dribnenki, 1994).

Vitamin E is present in flax primarily as gamma-tocopherol (Daun and Przybylski, 2000), which functions as an antioxidant. The tocopherol content of flax is affected by the variety, maturity of the seed, growing region, growing conditions and method of extraction. The gamma-tocopherol content can range from 150- 800mg / kg flax. Carotenes are not detected in flax oil.

ALA-laden triglycerides in flaxseed oil are absorbed from the small intestine aided by bile salts. During this process, there is some deacylation of the fatty acids of the triglycerides. Reacylation takes place within the mucosal cells of the small intestine, and the ALA-laden triglycerides enter the lymph system in the form of chylomicrons. ALA-laden chylomicrons are transported from the lymph into the blood, where ALA is then carried in various lipid particles to the various cells of the body, where it gets metabolized to EPA and series-3 prostaglandins, series-5 leukotrienes and series-3 thromboxanes.

The flaxseed oil lignan SDG is metabolized by bacteria in the colon to enterolactone and enterodiol. These substances are absorbed from the colon and metabolized to several hydroxylated metabolites in the body.

Clinical studies with flax oil have not confirmed the results of reduction in total and LDL cholesterol observed with seed powder. Thus it is thought that the fiber content is more important than ALA content of the oil. In ALA-rich flax oil, which contains no fiber, the cardio-protective effects of ALA may have less to do with lowering blood cholesterol and more to do with other important actions of ALA that reduce CHD risk (Morris and Vaisey-Genser, 2003). For instance, ALA helps limit inflammatory reactions that contribute to arteriosclerosis. Some potential mechanisms include the following:

1. ALA blocks the production of pro-inflammatory eicosanoids. Caughey et al. (1996) reported a significant decrease of 30% in the concentration of thromboxane B2 in immune cells of 28 healthy men who consumed 13/4 tbsp of flax oil daily for four weeks. Thromboxane B2 is a metabolite of thromboxane A2, an eicosanoid derived from arachidonic acid. Thromboxane A2 is one of the most potent constrictors of blood vessels and promoters of platelet aggregation known (Ross, 1999).

2. ALA blocks the release of several inflammatory cytokines. The concentrations of tumor necrosis factor-α (TNF-α) and interleukin 1-β (IL-1β) in immune cells decreased 26% and 28%, respectively, when 28 healthy men consumed flax oil for four weeks as described previously (Caughey et al, 1996). TNF-$\alpha$and IL-1β are both at the center of the body's response to inflammatory stress (Brodsky, 1999).

3. Apo-lipoprotein B (apo-B) decreased significantly by 19% when eight men with normal blood lipid levels consumed a mixture of vegetable oils including flax oil (Chan et al, 1991). Apo B-containing lipoproteins increase the risk of atherosclerosis (Semenkovich, 1999).

4. Systemic arterial compliance improved when 15 obese men and women consumed flax oil for four weeks (Nestel et al. 1997). Systemic arterial compliance is a measure of the flexibility of blood vessels. This non-invasive method provides information about the health of the circulatory system. Although the average intake of ALA by these obese volunteers would not be achieved easily in the real world – their intake was 20 g ALA/day which can be obtained from 21/2 tbsp flax oil – the main study finding was impressive: The increase in systemic arterial compliance with flax oil was similar to that achieved through exercise training. .

Compared to corn, safflower and fish oil, flax oil and ground flax had better inhibition of the growth and development of mammary tumors in animal studies (Cameron et al, 1989; Fritsche and Johnston, 1990). The size of established breast tumors in mammary tissue was reduced by more than 50 % when rats were fed flax oil for seven weeks (Thompson et al, 1996). Thompson et al (2000) reported reductions in breast cancer cell proliferation and tumor growth. The ALA intake has been found to be inversely proportional to the breast cancer risk (Klein et al, 2000). The molecules that arise when omega-3 fatty acids get metabolized provide a range of potential anti-cancer benefits.

Two components of flax, ALA and lignans, affect immune cells and compounds like eicosanoids and cytokines that control immune reactions. The ALA and lignans in flax may play a beneficial role in the clinical management of autoimmune diseases like arthritis and systematic lupus erythematosus (Ingram et al. 1995). In rats and mice, ground flax and flax oil reduced kidney inflammation and improved kidney function (Ingram et al, 1995; Ogborn et al. 1998, 1999, 2002).

It may also help prevent elevated blood pressure by inhibiting inflammatory reactions that cause artery-hardening plaque and poor circulation. Nestel et al (1997) found significant reduction in blood pressure after four weeks of intervention with flax oil. ALA content of adipose tissue is reduced in hypertensive patients (Berry and Hirsch, 1986). Further studies are required to confirm this effect.

In the few studies conducted to date, consuming flax oil or ground flax did not affect hemostatic factors such as platelet clumping (aggregation) (Bierenbaum et al, 1993; Freese and Mutanen, 1997), bleeding time (Kelley et al, 1993; Freese and Mutanen, 1997) or coagulation of the blood (*Allman-Farinelli et al, 1999; Freese and Mutanen, 1997*). However, Freese and Mutanen (1997) reported that consumption of flax oil produced hemostatic effects that were similar to those seen with the consumption of fish oil, leading the researchers to conclude that the effects of ALA on hemostatic factors were mainly in the same direction as the effects of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA).

Flaxseed has recently gained attention in the area of cardiovascular disease primarily because it is the richest known source of both alpha-linolenic acid (ALA) and the phytoestrogen, lignans, as well as being a good source of soluble fiber. As a result, there is an increasing tendency of comparing fish oil and flax oil with a perception that former is better than later. The findings of clinical studies (Caughey et al. 1996) suggest that ALA is not as potent in its biologic effects as the longer-chain omega-3 fatty acids, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). However, the biologic effects of ALA in this study were achieved by consuming a reasonable level (13/4 tbsp) of flax oil daily, whereas the effects observed during the fish oil period were achieved with a pharmacological or drug level of EPA and DHA obtained from fish oil. The biologic effects of ALA, EPA and DHA might be similar if clinical studies used realistic dietary levels of EPA and DHA (Morris and Vaisey-Genser, 2003). Further research on this aspect of bio-equivalence of omega-3 fatty acid is warranted.

Whole and ground flax are getting popular in a variety of food products, including bakery products, cereals, pasta, energy bars and dry mixes for pancakes, muffins and waffles. Flax oil products are also available in health food market and over the Internet. Innovative products incorporating flax seed-whole, ground or oil-are constantly emerging. The following are a few examples of the same.

- Polyunsaturated Spreads fortified with flax-derived-omega 3 fatty acids in UK market (French, 2004). Jones et al (2000); Hendriks et al (1999) and Weststrate & Meijer (1998) have reported around 10-15 percent reduction in LDL within three weeks of the consumption.

- Soy beverage with flax oil, providing 500 mg of omega-3 fatty acids per cup (Soya World, 2004).

- Frozen dessert, in which flax oil replaces 15% of the milk fat in the ice cream-like product (Hall and Schwarz, 2002).

- Solin oil, low in alpha-linolenic acid (ALA), is suitable for inclusion in margarine and in some commercial frying applications (Dean, 1996).

- Functional oil blend containing flax oil, may lower blood lipids (St-Onge et al, 2003) and body weight in healthy overweight men.
  -Plant based oil blend with 2:1 ratio of omega-3 to omega-6 fatty acids is an alternative to Fish oil (Flax Focus, 2003 a)

In a clinical trial, inclusion of Cholesterol reducing Flaxseed cooking oil (includes extracts of tropical oils, pure olive oil, coconut oil, phytosterols, and 5% flax oil) resulted in 13% decrease in cholesterol. This reduction is almost three times greater than that attributed in past studies to olive oil (4.5%) (Flax Focus, 2003 b).

One tbsp of flax oil provides 8 g ALA. As little as ½ tsp of flax oil daily provides 1.3 g ALA, an amount that is more than sufficient to meet the Adequate Intake of ALA for adults (Institute of Medicine, 2002). This intake level is consistent with that used in several clinical studies, where volunteers consumed 1–2 tsp flax oil daily for between four weeks (Freese and Mutanen, 1997) and three months (Layne et al, 1996, Goh et al, 1997,Clandinin et al, 1997). The mean daily intake of flax oil by volunteers in many clinical studies was about 25 g, which is roughly equal to a daily intake of about 11/3 tbsp of flax oil. Children can consume about 1/ 4 tsp of flax oil daily, while pregnant and lactating women can consume about ½ tsp of flax oil daily to achieve the Adequate Intake of ALA.

Flax oil is best used in cold applications like fruit smoothies, salad dressings and vinaigrettes. Stir-frying with flax oil can be done, provided the frying temperature is not greater than 150°C (Hadley, 1996). A temperature of 150°C is equivalent to 300°F. Most foods are fried at temperatures of 177° to 196°C (350° to 385°F) (302). Therefore flax oil is not recommended for frying. Alpha-linolenic acid (ALA) can withstand the temperatures of baking with little effect on fatty acid composition or oxidation. Moreover, there is no evidence of the formation of new *trans* forms of ALA or other undesirable fatty acid by-products with severe heat treatment (Cunnane, 1995; Chen et al. 1994; Ratnayake et al. 1992; Manthey et al. 2002).

After filtering, the oil is shipped in opaque bottles that do not require refrigeration. Once the bottle has been opened, the oil must be refrigerated to maintain freshness (Morris and Vaisey-Genser, 2003). Most manufacturers recommend using flax oil within six weeks of opening the bottle.

Individual countries have their own regulations that govern the use of flax in their food supplies.. In Canada, flax is regulated as a food and not as a food additive. There is presently no regulation that limits the level of flax in foods. In the U.S., the GRAS status of flax has been declared by food manufacturers (Vanderveen, 1995). The FDA has indicated that it has no objection to its use in foods up to 12% flax. FDA has indicated that refined solin oil is GRAS under the conditions of use proposed by United Grain Growers, now operating as Agricore United (Food and Drug Administration, 1998). The precaution while use of flax oil is warranted due to its very high ALA content.

Following certain nutritional guidelines, including increasing the amount of omega-3 fatty acids in one's diet and reducing the omega-6 to omega-3 ratio, may allow a group of cholesterol lowering medications known as "statins" (such as atorvastatin, lovastatin, and simvastatin) to work more effectively (Juhl et al, 2002).

Taking omega-3 fatty acids during cyclosporine therapy may reduce toxic side effects (such as high blood pressure and kidney damage) associated with this medication in transplant patients. Treatment with omega-3 fatty acids may reduce the risk of ulcers from non-steroidal anti-inflammatory drugs (NSAIDs).

Conclusion

In spite of being one of the major and ancient oilseeds with varied health benefits, flaxseed oil has not received due attention from nutrition researchers in India. Human consumption of flax seed / oil in the United States and Canada is increasing rapidly for its high dietary fiber, α-linolenic acid, and the anti-carcinogenic lignans. Flaxseed oil consumption is doubling annually and research is continuing to determine the health benefits of human consumption of flaxseed and its oil. It is time now that this jewel is dug out from its prolonged industrial habitat and rediscovered for its diverse nutraceutical potential. Vegetarians who add flax oil to the diet can improve the omega-3 fat content of their tissues.

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COCONUT OIL

Rajeswari M
College of Home Science, Nirmala Niketan, Mumbai-400020.

Indian mythology credits the creation of the tall coconut palm with its crown of Leafy fronds to the sage Viswamitra, to prop up his friend king Trishanku when the latter had been thrown out of heaven by Indra for his misdeeds. Botanists place the origin of the coconut palm in Papua New Guinea area in some very distant past. The plant evolved as far back as 20 million years ago, long before man appeared on earth to judge from fossil remains including one from Rajasthan (Achaya, 1998) Coconut served many human communities around the tropics in variety of ways. Coconut is potable, palatable and portable! It has been suggested as the 'milk bottle on the door step of mankind' (Haries, 1981).

Production: The Coconut palm is one of the most useful plants in the world. It is grown in more than 80 countries of the world. Indonesia and the Philippines are the first and the second largest coconut producing country in the world. India being the third largest coconut producing country having an area of about 1.78 million hectares under the crop. Annual production is about 7562 million nuts with an average of 5295 nuts per hectare. It is mainly cultivated in Philippines, Indonesia, India, Sri Lanka, Thailand, Malaysia, Fizi, Samoa, Solomon Islands etc. The major coconut growing states in India are Kerala, Tamilnadu, Karnataka, A.P, Maharashtra, Orissa, West Bengal, Assam, Goa, Daman and Diu, Lakshwadeep, Gujarat. Kerala tops in production accounting 54 percent of total production in the country.

Kerala is the largest producer of coconuts in India producing 5496 Million Nuts followed by Tamilnadu (3158.4 Million Nuts), Karnataka (1754.2 Million Nuts), and Andhra Pradesh (1092.7 Million Nuts) as they have taken 2nd, 3rd and 4th position respectively. Central Kerala town Kochi is a major trading center for coconut oil and copra. Giving focus on productivity, Maharastra comes in 1st position (914548 Nuts/ha.), West Bengal in 2nd position (13490 Nuts/ha.) and Andhra Pradesh in 3 rd position (10660 Nuts/ha.). Kerala being a major coconut producing state its productivity is not so high (5870Nuts/ha.).

At present India produces about 10 lakh tonnes of copra annually of which about 2 lakh tonnes is of confectionery or edible grade and 8 lakh tonnes milling grade. The edible copra produced in Malabar region is specially preferred in India and abroad because of its attractive colour and sweetness.

Based on the per capita intake of coconut oil in 1985 as reported by Kaunitz (1992), the per capita daily intake of lauric acid can be approximated. For those major producing countries such as the Philippines, Indonesia, and Sri Lanka, and consuming countries such as Singapore, the daily intakes of lauric acid were approximately 7.3 grams (Philippines), 4.9 grams (Sri Lanka), 4.7 grams (Indonesia), and 2.8 grams (Singapore). In India, intake of lauric acid from coconut oil in the coconut growing areas (e.g., Kerala) range from about 12 to 20 grams per day (Eraly 1995), whereas the average for the rest of the country is less than half a gram. An average high of approximately 68 grams of lauric acid is calculated from the coconut oil intake previously reported by Prior et al (1981) for the Tokelau Islands. Other coconut producing countries may also have intakes of lauric acid in the same range (Enig.2000).

Physical and chemical characteristics

Coconut oil contains a high proportion of glycerides of lower fatty acids. The chief fatty acids are lauric (45%), myristic (18 %), palmitic (9%), oleic (8%), caprylic (7%), capric (7%) and stearic (5%). There is also a minute amount of tocopherol. The natural volatile flavour components of fresh meat and oil are mostly delta lactones.

Commercially the extraction of oil from copra or dried or smoked coconut meat is one of the oldest seed - crushing industries in the world. Extraction methods range from simple techniques employed in villages to modern high-pressure expellers and prepress or solvent extraction plants that can process more than 500 tonnes of copra a day. In Indonesia, some processors cook chopped fresh kernel in previously extracted coconut oil before pressing. Coconut oil as it is ordinarily prepared in tropical countries ranges from colourless to pale brownish yellow in hue. In temperate climates or air conditioning, it appears as a greasy somewhat white or yellowish solid fat that has a melting point between 20–26^{0}C. Coconut oil is refined, bleached and deodorized using standard vegetable oil processing technology. If coconut oil is cooled under crystallization part of the oil produces a semi solid mass, which is then separated under hydraulic pressure. The solid fraction coconut stearine is a harder fat with a higher melting point and the liquid fraction is coconut olein has correspondingly lower melting point.

At present India produces about 11614 tonnes of coconut oil annually, of which about 50 per cent is absorbed by the toiletry sector (in hair oils, toilet soaps, chemicals for shampoos, etc), 35 per cent by the households for cooking purposes and 15 per cent is used by confectionery and ice-cream industry. At one time, the toilet soap industry used to consume 23 per cent of the coconut oil produced in the country but now its consumption has dropped to just 5 per cent. The use of coconut oil as hair oil in India, however, is rising. Coconut oil is an important cooking medium in Southern parts of the country especially in Kerala.

The difference in coconut oil price in between domestic and international makes a negative impact on domestic market. Since the price of coconut oil in the international market is very much lower than the domestic price, the quality and attractiveness of consumer packs are important factors to compete in the world market. While the demand for coconut oil for cooking purpose is elastic, its demand as hair oil is inelastic.

As a functional food, coconut has fatty acids that provide both energy (nutrients) and raw material for antimicrobial fatty acids and monoglycerides (functional components) when it is eaten. Desiccated coconut is about 69% coconut fat, as is creamed coconut. Full coconut milk is approximately 24% fat.

Approximately 50% of the fatty acids in coconut fat are lauric acid. Lauric acid is a medium chain fatty acid, which has the additional beneficial function of being formed into monolaurin in the human or animal body.

Monolaurin is the antiviral, antibacterial, and antiprotozoal monoglyceride used by the human or animal to destroy lipid-coated viruses such as HIV, herpes, cytomegalovirus, influenza, various pathogenic bacteria, including listeria monocytogenes and helicobacter pylori, and protozoa such as giardia lamblia. Some studies have also shown some antimicrobial effects of the free lauric acid.

More recently, lauric acid has been recognized for its unique properties in food use, which are related to its antiviral, antibacterial, and antiprotozoal functions.

Capric acid is another medium chain fatty acid, which has a similar beneficial function when it is formed into monocaprin in the human or animal body. Monocaprin has also been shown to have antiviral effects against HIV and is being tested for antiviral effects against herpes simplex and antibacterial effects against chlamydia and other sexually transmitted bacteria.

Now, capric acid, another of coconut's fatty acids has been added to the list of coconut's antimicrobial components. Also, approximately 6-7% of the fatty acids in coconut fat are capric acid. These fatty acids are found in the largest amounts only in traditional lauric fats, especially from coconut. Also, recently published research has shown that natural coconut fat in the diet leads to a normalization of body lipids, protects against alcohol damage to the liver, and improves the immune system's anti-inflammatory response.

Clearly, there has been increasing recognition of health - supporting functions of the fatty acids found in coconut. Recent reports from the U.S. Food and Drug Administration about required labeling of the trans fatty acids will put coconut oil in a more competitive position and may help return to its use by the baking and snack food industry where it has continued to be recognized for itsfunctionality

Therapeutic value

Through the years metabolic and animal studies have claimed that dietary saturated fats increase serum cholesterol levels, thereby supposedly establishing the link. But the scientific basis for these relationships has now been challenged as resulting from large-scale misinterpretation of the data (Enig 1991, Mann 1991, Smith 1991, Ravnskov 1995).

Coconut oil providing 24% of energy fed to 83 adult normocholesterolemics (61 males and 22 females) increased the total cholesterol by 17% (169.6 to 198.4 mg/dl), HDL cholesterol by 21.4% (44.3 to 53.8 mg/dl), and decreased the LDL-C/HDL-C ratio by 3.6% (2.51 to 2.42) (Ng et al. 1991). Lauric acid (C12:0) and myristic acid (C14:0) from coconut oil supplying approximately 5% of energy showed an increase in total serum cholesterol from 166.7 to 170.0 mg/dl (+1.9%), a decrease in low-density lipoprotein cholesterol (LDL-C) from 105.2 to 104.4 mg/dl (-0.1%), an increase in high-density lipoprotein cholesterol (HDL-C) from 42.9 to 45.6 mg/dl (+6.3%). There was a 2.4 % decrease in the LDL-C/HDL-C ratio from 2.45 to 2.39 indicating a favorable alteration in serum lipoprotein balance (Sundaram et al. 1994). Kurup and Rajmohan (1995) studied the addition of coconut oil alone to previously mixed fat diets and reported no significant difference in the lipid profile. It is possible that serum total cholesterol, LDL cholesterol and especially HDL cholesterol may be raised in individuals with low serum cholesterol and of total cholesterol and LDL cholesterol is lowered in hypercholesterolemics (Enig, 1996).

When coconut oil was fed as 7% of energy to patients recovering from heart attacks, the patients had greater improvement compared to untreated controls, and no difference compared to patents treated with corn or safflower oils. Populations that consume coconut oil have low rates of heart disease. Coconut oil may also be one of the most useful oils to prevent heart disease because of its antiviral and antimicrobial characteristics (*JAMA* 1967 202:1119-1123; *Am J Clin Nutr* 1981 34:1552).

Lim-Sylianco (1987) has reviewed 50 years of literature showing anticarcinogenic effects from dietary coconut oil. These animal studies show quite clearly the nonpromotional effect of feeding coconut oil. Reddy et al (1984) found coconut oil to be more inhibitory than MCT oil to induction of colon tumors by azoxymethane. Chemically induced adenocarcinomas differed 10-fold between corn oil (32%) and coconut oil (3%) in the colon. Both olive oil and coconut oil developed the low levels (3%) of the adenocarcinomas in the colon, but in the small intestine animals fed coconut oil did not develop any tumors while 7% of animals fed olive oil did. Studies by Cohen et al (1986) showed that there was no progress in chemically induced breast cancer when fed coconut oil.

Although Coconut Butter has long been touted as unhealthy, many health researchers are changing their minds. Current studies indicate that when coconut oil is unprocessed, it can be part of a healthful diet. Coconut oil can be used in moderation, one to two tablespoons per week, by most people who consume plenty of essential fatty acids.

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GROUNDNUT OIL

Groundnut oil, also known as peanut, is extracted from one of the world's most popular crops. It has been found in the excavations dated 1,000 BC in coastal Peru. Its cultivation began between 300 and 2500 BC in the Peruvian desert oasis. Early Spanish and Portuguese accounts record the presence of this crop through the West Indies and South America. In the 16[th] century, the Portuguese took it from Brazil to West Africa and Spaniards took it across the Pacific to the Philippines. From there, it spread to China, Japan, Malaysia and India and as far as Madagascar. India leads the world in groundnut production and about 40 per cent of the groundnut entering the world commerce is from India.

Fat and oil consumption averages less than 5 kg per capita per year. It has been estimated that in the year 2000, approximately 34 million Mt of groundnuts were produced worldwide, of which 15 million Mt were produced in China, 6 million Mt in India, 2 million Mt in Nigeria, 1.5 million Mt in United States of America and the rest mostly in other countries. Thus, China and India together are the world's leading groundnut producers accounting for nearly 60 percent of the production and 52 percent of the crop area. India cultivates about 7.74 million hectares and produces 7.61 million tonnes of groundnut with the productivity level of 991.8 kg ha. South Africa is the major producer in Africa, while in Latin America almost one half of the total groundnut produced in that region may be credited to Argentina. As per United States department of Agriculture sources, the global production of groundnut oil in Feb 2001/2 was 4.77 million metric tons. Among the developing countries Egypt has the highest productivity and capacity to produce groundnuts.

Over half of the groundnut harvested worldwide is crushed for oil and a substantial quantity of groundnut produced in developing countries is traded in domestic markets. According to the Solvent Extractors Association of India, the estimated production of groundnut oil is 13.2 lakh tons for the year 2003/ 04, almost double that of the 7.3 lakh tons for the year 2002/3. Domestic export figures by the same source of groundnut oil are 1.03 lakh tons in the year November 03 to June July 2004.

The seeds yield from 42 to 50% of oil by cold expression, but a larger quantity is obtained by heat, although of an inferior quality. The seeds being soft facilitate mechanical expression, and where bisulphide of carbon or other solvent is used, very pure oil is obtained. The expressed oil is limpid, of a light yellowish or straw color, having a faint smell and bland taste; it forms an excellent substitute for olive oil. The expeller and the solvent extraction techniques are the two main methods that are employed for oil extraction.Solvent extracted oil needs to refined to remove the traces of solvent used for extraction before it is used for edible purposes.

The quality of peanuts is being improved. Newer peanut varieties, with higher yields and grades, disease, insect, virus, nematode, drought and aflotoxin resistance, improved shelling characteristics, better processing qualities, longer shelf life and enhanced flavor and nutrition, have been developed using conventional breeding procedures and genetic engineering.

General characteristics of groundnut oil are as follows:

Specific Gravity at 25/25 ^{0}C	0.910 – 0.915
Refractive index	1.0-4670-1.4700
Iodine number	84 – 100
Saponification number	188 – 195
Unsaponifiable matter	not over 1.0 %

Fatty acid composition:

Saturated Fatty Acids = 24 g/100g.
Monounsaturated fatty Acids = 50 g/100g.
The predominant MUFA in groundnut oil is oleic acid
Polunsaturated Faty Acids = 26g/100g. Mainly n6, n3 component is nil.

Broadly speaking, people from the Western and Southern states generally prefer groundnut oil, though some pockets in the south use coconut and sesame oil. There fore groundnut oil is mainly consumed in the states of Gujarat, Maharashtra, Rajasthan, Madhya Pradesh, West Bengal and to some extent in Bihar, Karnataka, Andhra Pradesh & Tamil Nadu.

Therapeutic value:

In addition to bioactive fatty acids, peanut oil contains lipid-soluble compounds such as tocopherols, phytosterols, resveratrol and squalene, which have a number of health benefits for humans.

Phytosterols were first recognised in the 1970s for their ability to absorb dietary cholesterol in the blood, thereby protecting against cardiovascular disease. Phytosterols are found in high concentrations in peanut oil. Recent research has shown that phytosterols

- Inhibit cancer growth
- Protect against heart disease by lowering high cholesterol levels caused by either dietary habits or because of genetic factors and
- even protect from colon, breast and prostrate cancer.

Phytosterols are the equivalent of animal cholesterol in the body but they are absorbed at a much lower rate (5% to 10%), than cholesterol (50%)from the blood into the body (Awad et al 2000). A recent study from Penn State University shows that diets that include 2-3 servings daily of peanuts or peanut butter lowered cholesterol by 11% to 14% (Kris-Etherton et al 1999). Phytosterols lower cholesterol in two ways: 1. by blocking the absorption of dietary cholesterol that is circulating in the blood, and 2. by reducing the reabsorption of cholesterol from the liver, which the body naturally produces.

Kris-Etherton et al (1999) found that diets high in groundnuts plus its butter or oil are as effective as diets high in olive oil in protecting against heart disease. The researchers compared the effects of five diets - low fat, olive oil, groundnuts plus its butter, its oil, and typical American with 35 percent fat - on the blood lipids of 22 healthy men and women, ages 21-54, many of whom had slightly elevated blood cholesterol at the beginning of the study. The findings showed that diets high in groundnut products offered more heart disease protective benefits than the very low fat diets. The study also found that diets using groundnut oil lowered total and LDL cholesterol and triglyceride levels without lowering the beneficial cholesterol levels. Interestingly this study found that a low fat diet lowered both LDL and HDL levels. Overall, the peanut diets reduced the risk of cardiovascular disease by 21%, whereas a low-fat diet reduced the risk by only 12%. A more recent study by Alper, Mattes (2003) reported similar results.

The Nurses' Health Study recently discovered that consumption of peanuts and peanut butter is inversely associated with the risk of type 2 Diabetes after adjustment for risk factors (Jiang et al. 2002).

Therefore Groundnut oil being 50 % MUFA oil has the many benefits of MUFA. The data from both dietary and plasma fatty acids showed that while the requirements of linoleic acid (18:2 n-6, LA) were fully met due to their high levels in cereals and many vegetable oils, alpha-linolenic acid (18:3, n-3 ALNA) intakes were low. Long-term high intakes of ALNA or long chain n-3 polyunsaturated fatty acids (LCn-3 PUFA) reduce the risk of coronary heart disease (CHD). Metabolic studies were therefore conducted in Indian subjects to investigate the effects of using fish oils (LC n-3 PUFA) and ALNA rich oils (canola oil and mustard oil, MO) in comparison to oils which have negligible ALNA (groundnut oil, GNO and palmolein, PO) on plasma lipids, essential fatty acid (EFA) status and platelet aggregation. The results showed that at a level of 6-7 energy per cent LA, about 0.2 to 0.5 energy per cent LC n-3 PUFA or 1.4 energy per cent ALNA produced anti-atherogenic effects. However, high levels of erucic acid (22:1, EA) present in MO prevented these beneficial effects. Since absolute levels as well as the ratio of n-6 to n-3 PUFA are essential for optimal health, the use of more than one oil (correct choice) is recommended. However, it is necessary to evaluate the long-term health benefits of the recommended oil combinations before permitting commercial preparation and endorsing health claims. The long-term study revealed that MUFA oils reduce LDL, increased the A-1Apolipoprotien constituent of HDL and makes LDL more resistant to free radical damage.

Recent research has identified the amount of beta-sitosterol (SIT) in peanuts and peanut products. SIT is the most widely found phytosterol in foods and new research shows it may help protect against colon, breast and prostate cancer (Wolter, Stein 2002, Delams et al. 2002). Researchers at the State University of New York in Buffalo examined the SIT content of several peanut products. They found that peanut oil contains about 190 mg per 100 gm. making it a good source of SIT as well (Awad et al 2000). In fact, refined (or pure) peanut oil contains about 38% more protective SIT than refined olive oil (Awad et al 2000). As plant components, phytosterols may offer protection against cancer by several different means. These include inhibiting cell division, stimulating tumour cell death and modifying some of the hormones that are essential for tumour growth (Awad et al.2000).

One ounce serving of peanuts delivers as much as 17.5% of the Recommended Daily Intake of folate while peanut butter delivers even more. Studies show that folate consumption may aid in decreasing incidence of stroke and coronary disease among the elderly.

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MAHUA OIL

Deepali Kotwal, Sabiha Vali, N.V. Shastri
Dept. of Home Science, Nagpur University

Mahua (Madhuca latifolica) is a forest tree found abundantly in several parts of India. It is common in the monsoon forests of Western Ghats. The flowers are used in the fermentation of country liquor. Mahua seeds have been identified as good sources of oil containing about 50 % pale yellow semi solid fat. The seed oil is commercially known as 'Mahua Butter'. The oil content of the seed varies from 33 to 43 % of the weight of the kernel. It is known to be consumed by certain tribal people in some parts of India. Mahua oil finds its use in Arthasastra (Achaya, 1998).

The seeds are abundantly produced (about 1.11 million tonnes) and around 400,00 tonnes of oil is produced every year. The seeds are separated from the fruit wall by pressing and then drying and shelling to get the kernel (70 % of the weight of the seed). The quality of extracted oils depends largely on the storage conditions of the kernels, which are susceptible to both fungus and insect attack. Fresh mahua oil from properly stored seeds is yellow in colour. At temperatures prevailing in most parts of India during the major part of the year, the oil is fluid. But in cold weather, the oil solidifies to a butter consistency by throwing out a deposit of stearine and hence mahua tree is also known as 'The Indian Butter tree".

The semi solid fat is rich in oleic and linoleic acids. Mahua is solid plastic fat having more saturated fats than groundnut oil. The raw mahua oil appears to have a nutritional quality comparable to ground nut oil as indicated by growth studies on albino rats and other biochemical parameters. (Waikar, 1986, NIN, 1986-87). As early as in 1938, Hilditch and Ichaporia studied the fatty acids and glycerides in mahua oil. Kane (1966) demonstrated the presence of four major characteristic fatty acids in Mahua oil. They are palmitic – 23 %, stearic 19 %, oleic 43 % and linoleic 14 %. Mahua oils are non-drying fats but are semi solid in consistency. Their partial hydrogenation under controlled conditions would convert them into plastic or non-plastic fats. The solid stearine portion obtained by fractionation is mostly employed when mahua oil is used in cocoa butter substitute (Bringi, 1987)

Adhikari and Adhikari (1989) reported that the vegetable oleins were obtained during the fractionation process employed for making cocoa butter substitute from mahua. Although the solid stearine fractions were utilized for making confectionery fats, the liquid plein portions obtained could be utilized for direct cooking purposes. Outlets for these oleic portions would not only ensure total utilization of these non-traditional oils, but would also provide an extension of edible oil supplies.

Deep fat frying experiments indicated that the oleic fraction showed a slow build up rate of total polar material and were quite suitable for such use. The normal analytical characteristics and fatty acid compositions of the oleic portions obtained from mahua fats were investigated under appropriate conditions of time and temperature. Mahua olein was reported to contain palmitic (18%), stearic (21%) and oleic (38%) acids. Studies have also shown that without an anti oxidant addition the oleins could be stored for 405 months and with 0.01 tertiary butyl hydroquinone, the storage life could be prolonged to over one year.

The physico chemical properties of the oil are similar to those of other edible oils. The oil has been evaluated for safe edibility and nutritional quality and is comparable with ground nut oil (Table 1).

The oil is used for cooking purposes. It is one of the ingredients of hydrogenated vanaspati.. It is used as an adulterant for ghee, for which purpose it is clarified with buttermilk to mask the disagreeable odour. It is mainly used in the manufacture of soaps. It is also used as illuminant and hair oil. The oil finds its use in medicine also (Wealth of India, 1962, Tiwari, 1975).

TABLE 1. PHYSICAL AND CHEMICAL CHARACTERISTICS OF RAW AND OXIDIZED MAHUA OIL

Physico-chemical characteristics	Raw	Heated	Fried
Colour, 280 nm	0.21	0.73	1.16
Viscosity	79	96	98
Smoking point	228	217	219
Acid value	7	15.8	12.1
Peroxide value, meq O2/ Kg of oil	2.15	7.72	6.96
Iodine value	59.80	52.23	50.76
Saponification value	195.53	211.81	217.12
Refraction Index,40 deg C	1.46	1.46	1.46
Unsaponifiable Matter %	3.2	3.5	3.5
CDHP(Conjugated Diene hydroperoxides),234nm	0.32	0.38	0.48

The rats of either sex fed on raw Mahua oil for a period of 3 months showed good growth. Thermally oxidized Mahua oil (at 180 + 5 deg C for 8 hrs) when ingested by either sex at a 10 % level for a period of 3 months exhibited alterations in biochemical and histological status. When heated mahua oil fed to male rats exhibited moderate hepatic hepertrophy showed unilateral testicular maturation arrest.

Consumption of fried Mahua oil reduced significantly the food intake and hence the weight gain of female rats. However rats of both sexes exhibited hepatic hypertrophy and intestinal changes, the later being more dominated in male rats. Effect of male sterility due to consumption of heated mahua oil was also observed. But according to Ravindranath ,2002 multigeneration reproduction studies in rats indicated poor reproductive performance and temporary male sterility in rats. But on withdrawal of mahua oil from the diet and rehabilitation, the male animals regained their fertility. No other adverse toxicological effects were reported.

The oil is refined to an edible grade and the Central Committee for Food Standards (CCFS) in India permits its use as edible oil. It is widely used in the hydrogenation industry in products for human consumption.

The safety evaluation of hydrogenated vegetable oil containing 30 % mahua oil did not show any significant adverse effects in reproductive performance on growth. Therefore, mahua oil added at a level of 30% in hydrogenated vegetable oil may not pose any health hazard.

Therapeutic value

Mahua oil is much valued by hill tribes in the treatment of skin diseases. It is applied to the arms of children to allay the extreme itchiness sometimes caused by the presence of intestinal worms (Watt, 1889). The oil is sweet; acrid cures kapha, bilious fever, burning sensation (Basu and Kirtikar, 1818). This oil is also used for application in skin diseases and to the head in cephalgia and is often applied in chronic rheumatism. It acts as a laxative and may be used in habitual constipation and hemorrhoids (Nadkarni, 1954). The oil is emollient and laxative and is useful in dermatopathy, rheumatism, cephalgis and hemorrhoids

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GRAPESEED OIL

Grape seed oil (*Vitis vinifera*) has originated from France. It is a by-product of wine production and has been favorite edible oil in Europe for hundreds of years due to its many fine qualities. Low heat expeller pressed oil has a shelf life of 1-2 Years. It has an effervescent green colour with a characteristicodour. Only about 0.2 % as linolenic acid (omega 3) is present in grape seed oil. The omega-9 family (oleic) constitutes 19 % and the saturated fatty acids about 12 % (palmitic - 7.2 % and stearic - 4.8 %). Fats like grape seed oil with 68 % - 76% linoleic acid are proved to reduce blood cholesterol levels by 20 %. Grape seed oil reduces the blood levels of LDL (Bad) cholesterol while increasing the levels of HDL (good) cholesterol. It also lowers total blood cholesterol levels. The Massachusetts Male Aging study showed that as HDL levels decrease, the probability of impotence increases (Anonymous, 1994). Many studies have confirmed that for each percent increase in HDL, there is a 3-4% decrease in the incidence of cardiac events.

Nash (1990) and Nash and Nash (1993) have shown that subjects, who included a small amount of grape seed oil daily in a low-fat diet over a four-week period, experienced an increase of 13%, in their HDL and a decrease of 7% in their LDL. The oil reduces platelet aggregation and helps to prevent hypertension caused by excess sodium. Also helps to normalize lesions occurring from obesity and diabetes. It is ecologically sound because it is made from grape seeds after the wine pressings (Anonymous, 1976, 1977). Grape seed oil is naturally rich in Vitamin E a potent antioxidant (a tb sp. of the oil provides the RDA). It is also known to prevent heart disease and cancer as well as to promote healing and healthy skin and muscles. This oil contains traces of proanthrocyanidins most of which exist as glycosides and are water-soluble. So some of the non-glycosidic components (aglycons) get extracted with the oil. Recent studies show that proanthrocyanidins are very potent antioxidants that protect tissues from a range of oxidative injuries such as CVD and counteract the negative effects of high cholesterol on the heart.

When oils and fats are to be used sparingly grape seed oil is of great value as in small amount it can give great health benefits. The shelf life depends on storage conditions and if the can or bottle is opened should be stored in a cool dry place. Grape seed oil can last for at least one year with no deterioration provided humidity and heat are avoided and kept out of direct light. Its stability and fluidity allow it to spread and mix with foods better and thus less is needed.

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CANOLA OIL

Canola is just a rapeseed variety (Brassica napus or Brassica campestris). Erucic acid and glucosinolates the two undesirable constituents are low in canola seed as compared to rapeseed. Traditional rapeseed is believed to be unsuitable for human consumption due to its high content of erucic acid. Erucic acid is a long chain monounsaturated fatty acid that has been shown to cause heart damage in experimental animals. Whereas traditional rapeseed oil contains 20-55 % erucic acid, canola oil contains less than 2 % erucic acid and is therefore considered safe.

The oil extracted from the canola seeds is suitable for cooking and baking at temperatures below 360°F as well as salad dressings, margarines and shortenings.

Monounsaturated fatty acid content of canola oil is excellent and the polyunsaturated fatty acids linoleic acid (LA, omega-6) and alpha-linolenic acid (ALA, omega-3) contents are also good, while the saturated fat is low (Table 1). High monounsaturated fat diets may be beneficial for controlling glucose levels in people with diabetes.

Canola is a good source of vitamin E. One tablespoon of canola oil provides approximately 2.9 mg of vitamin E, which is equivalent to approximately 1/5 of the recommended daily intake. It is also a good source of phytosterols, which interfere with cholesterol metabolism.

Canola oil is a valuable component of the diet as it helps in preventing cardiovascular disease by reducing the cholesterol levels and inhibiting the platelet aggregation. It has also been shown to protect against cardiac arrhythmias (loss of heartbeat rhythm, resulting in sudden death) in animal studies. It has been demonstrated that the oil results in lesser weight gain than beef fat in animals.

Canola was developed from the rapeseed plant through traditional plant breeding methods. In recent year, several genetically modified canola varieties have been developed and approved for sale in Canada and the United States. These canola varieties include lines with altered oil fatty acid compositions (high oleic/low linolenic acid canola and high lauric acid canola), herbicide resistant lines, lines displaying pollination control systems (male sterility and fertility restoration) and a phytase-expressing line.

TABLE 1 FATTY ACID CONTENT OF CANOLA OIL

Fatty Acid	% of Total
Saturated	7.1
Monounsaturated	58.9
Erucic Acid	0.6
Polyunsaturated	29.6
Omega-6 Linoleic Acid	20.3
Omega-3 ALA	9.3

Among various antioxidative substances of natural or synthetic origin, canolol was one of the most potent antimutagenic compounds when *Salmonella typhimurium* TA102 was used in the modified Ames test. Its potency was higher than that of flavonoids (e.g., rutin) and alpha-tocopherol and was equivalent to that of ebselen. Canolol suppressed ONOO(-)-induced bactericidal action. It also reduced intracellular oxidative stress and apoptosis in human cancer SW480 cells when used at a concentration below 20 microM under H(2)O(2)-induced oxidative stress. In addition, Canolol suppressed plasmid DNA (pUC19) strand breakage induced by ONOO (-), as revealed by agarose gel electrophoresis (Kuwahara et al. 2004).

Genetically modified canola oil is considered to be as safe as unmodified canola oil. Before a genetically modified food can be produced and sold in Canada or the United States, it must undergo a thorough environmental, livestock feed and food safety assessment.

It is mandatory that genetically modified foods be labelled when the composition of the food is modified (eg. high oleic/low linolenic acid canola oil) or when there are potential safety concerns associated with its consumption (eg. allergenicity). It is not required however, that foods derived from plants that were genetically modified to improve agronomic characteristics, without affecting food composition (eg: herbicide resistant plants) be labelled as genetically modified.

Canola oil is very inexpensive compared to most other vegetable oils. As cooking oil, it is much cheaper than olive oil and peanut oil and similar in price to soybean and corn oil. Canola oil is also much cheaper than other ALA-rich oils like flaxseed and hempseed oil.

Omega-3 fatty acids have been shown to provide benefits in a number of cardiovascular, immune/inflammatory and neurological disorders and have also been investigated as potential anti-cancer agents. Some of the ALA that is consumed in the diet is converted in the body to eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), the two long chain omega-3 fatty acids that are abundant in fish oil. Although fish oils have been shown be beneficial in the treatment and prevention of several diseases, it is still unclear whether or not ALA-containing foods provide equal benefits.

When consumed in normal amount with food, canola oil does not cause any side effects. If large amounts are consumed without food however, may upset stomach resulting in diarrhoea.

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COTTON SEED OIL

Cottonseed mills, in the late 1800's, used manual powered mechanical pressure to squeeze the oil from the seed. This was very labor intensive and at best recovered only one-half the oil contained in the seed. Today's mills are either screw press or solvent extraction types. The oil is removed from the meats leaving only 1-2 % oil in the meats. With the production of 790 lbs. of cottonseed per bale of cotton lint, modern mills can extract 140 pounds of cottonseed oil. This essentially doubles the oil production efficiency of the older mills. Many of the techniques used today in oilseed processing and edible oil refining can trace their roots back to the early work done on cottonseed and cottonseed oil.

Crude cottonseed oil requires further processing before it may be used for food. The first step in this process is refining. With the scientific use of heat, sodium hydroxide and a centrifuge (equipment used to separate substances through spinning action), the dark colored crude oil is transformed into transparent, yellow oil. This clear oil may then be bleached with special bleaching clay to produce transparent, amber colored oil. Upon further processing, the oil is deodorized or treated so it will remain clear and have no unwanted flavors.

Cottonseed oil, with its excellent bland to slightly nutty taste, is often used as a standard when comparing other oils. This bland flavor and mild odor provide a favorable contrast with most well known oils, particularly those oils containing linolenic acid (C-18:3), such as canola and soybean. Products with cottonseed oil as an ingredient, enjoy the dual benefits of superior flavor enhancement and extended natural stability, thanks to the functional properties of this traditional vegetableoil.

Cottonseed oil is used in several products. Depending on its stage of refinement, it can be used in snack foods, mayonnaise, margarine, baking or frying oils, and many other products. Cottonseed oil has superior nutritive qualities.

CORN OIL

Corn oil is minor oil in US as only about 3.4 % of the 1998 / 99 vegetable oil production. The U.S. vegetable oil market is dominated by soybean oil, which amounted to 87.9 % of the 1998/99 production. The other edible vegetable oils produced in the United States are rapeseed, cottonseed, peanut, and sunflower with 3.3, 3.2, 1.3, and 0.9% of the market, respectively. Worldwide, the major oils are rape, olive, cocoa, palm and palm kernel, peanut, and sunflower. Nevertheless, corn oil is important edible oil because of its positive health effects with the consumer..

Corn oil contains very little cholesterol. It's fatty acid content is 13% saturated, 62% polyunsaturated, and 25% monounsaturated. Studies using typical American foods have found that no vegetable oil is more effective than corn oil in lowering blood cholesterol levels

By removing free fatty acids and phospholipids from crude corn oil, the oil refining process gives corn oil one of the qualities consumers value most: its excellent frying quality and resistance to smoking or discoloration. Corn oil's high polyunsaturated fatty acid content has been widely publicized to have important nutritional and health benefits and resistance to developing off-flavours. The oxidative stability of corn oil during use, its desirable flavour along with its lack of sedimentation on refrigeration contribute to its demand among the consumers. The largest single use is bottled oil, followed by margarine and industrial snack-frying operations.

A majority of US-produced corn oil goes into cooking or salad oil. A significant portion also goes into margarines and shortenings, while restaurants are using a growing amount to replace animal fats in frying operations. Corn oil is not in use in India.

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LIPID PEROXIDATION OF DIFFERENT OILS ON HEATING

** Geetanjali Kelkar and ** Kalpana Joshi*
* SNDT College of Home Science, Karve Road Pune 411038
** School of Health Sciences University of Pune, Ganeshkhind Pune

Lipid peroxidation of oils has hazardous effects on health. The amount and extent of peroxidation is dependent on the fatty acid profile, processing (refined and unrefined), exposure to atmosphere and method of cooking. The degree of thermal stress determines the choice of cooking oil from the therapeutic aspects. The present study confirmed that oils with a high percentage of PUFA and MUFA are more labile to increased production of TBA. Raw unprocessed oils are less susceptible to thermal stress. Microwave heating shows lesser lipid peroxidation as compared to normal heating.

Oils are subjected to deterioration by heating, hydrolysis, and exposure to atmosphere. The hydrolytic rancidity in oils can be prevented by heating the oils to destroy the lipase enzyme that catalyses the hydrolysis of triglycerides (Srilakshmi, 2000). But heating can enhance oxidative lipid peroxidation of polyunsaturated fatty acids (PUFA) i.e. those that contain two or more double bonds. Heating oils to deep-frying temperatures results in thermal degradation with formation of volatile compounds - polymers, dimers, oxysterols, cyclic fatty acids and alkaline compounds soaps bonds (Grootveld et al, 1998).

Heating of oils to 180°C generates a variety of products such as aldehydes (alkanals, trans-2- alkenals and alka2, 4-dienals) and their conjugated hydroxy diene precursors. These are absorbed into systemic circulation and are the major contributing factor in pathogenesis of atherosclerosis and its associated sequelae, namely ischemic heart disease and peripheral vascular disease (Grootveld et al, 1998). Excessive intake of thermally oxidized oils in albino rats showed a remarkable increase in the levels of cholesterol, LDL, and decrease in HDL cholesterol (Srinivasan and Pugalendi, 2000). The present study therefore was undertaken to determine the effect of thermal stress on lipid peroxidation in raw and refined oils with different fatty acid make up.

Materials and Methods

Groundnut, safflower, mustard, coconut and sesame unrefined and refined branded oils were obtained locally. The raw unrefined and refined oils were exposed to thermal stress by direct heating and microwave heating (MW) and compared with unheated (UH) oils.

Extent of lipid peroxidation was measured by Thiobarbituric acid (TBA) reactivity. It was determined using the method given by (Luotola and Luotola, 1985. Phosphate buffer saline (PBS pH 7.4), Potassium Chloride (KCL 0.5M), Tris HCl (0.M), Trichloroacetic acid (TCA 30%) and Thiobarbituric Acid (TBA 52mM) (0.5ml each) were added to 0.5 ml of oil. The samples were incubated at 80° C for 30 min. The TBA chromogens were cooled and were read at 532 nm in a Shimadzu U V Spectrophotometer using appropriate blanks

Results and Discussion

Sesame and groundnut oils show a marginal increase in peroxidation in raw and refined oils. Safflower oil showed higher peroxidation. It is one of the most widely publicized oil due to its high PUFA content. The extent of peroxidation in raw and refined oils is attributed to the degree of unsaturation. PUFAs show peroxidation faster when exposed to heat and form toxic products such as aldehydes and peroxides. These are absorbed from the gut into systemic circulation and are the pro atherogenic (Grootveld et al, 1998).

According to the present study oils with high PUFA content show higher peroxidation in both raw and refined oils (Tables 1,2). Similar results were reported by Prabhu (2000).

TABLE 1. TBA REACTIVITY OF OILS AFTER DIRECT HEATING

Oil		Raw Oil			Refined Oil	
	Unheated	Heated	Diff.	Unheated	Heated	Diff.
Groundnut	0.020	0.065	0.045	0.097	0.163	0.066
Safflower	0.015	0.254	0.239	0.050	0.105	0.055
Mustard	0.246	0.405	0.159	0.527	0.605	0.078
Coconut	0.041	0.079	0.038	0.090	0.101	0.011
Sesame	0.051	0.158	0.107	0.063	0.303	0.240

TABLE 2. TBA REACTIVITY OF OILS AFTER MICROWAVE HEATING

Oil		Raw Oil			Refined Oil	
	UH	MW	Difference	UH	MW	Difference
Groundnut	0.020	0.060	0.040	0.097	0.248	0.151
Safflower	0.015	0.124	0.109	0.050	0.172	0.122
Mustard	0.246	0.641	0.395	0.527	0.862	0.335
Coconut	0.041	0.068	0.027	0.090	0.121	0.031
Sesame	0.051	0.109	0.058	0.063	0.191	0.128

Mustard oil is rich in unsaturated fatty acids and has a good w-6: w-3 ratio and also contains high percentage of α tocopherol. This makes it nutritionally beneficial, but little is known about its lipid peroxidation (Sodergren et 2001). The present study showed a higher degree of lipid peroxidation in raw, heated and microwave heated mustard oil. The higher degree of lipid peroxidation of mustard oil is ascribed to the higher MUFA content. Coconut oil showed less TBA reactivity probably due to its high SFA content and low PUFA content. This oil when subjected to oxidative stress generates little aldehyde products (Kurup, 1994). This may be the reason for lower incidence of atherosclerosis (Kaunitz, 1986, Mendis et al. 1989) in Kerala where the consumption of coconut oil is high. Peroxidation by microwave heating was comparatively less than by direct heating. Microwaves penetrate the food uniformly, setting all water molecules and other polar molecules in motion at the same time. Heating is uniform and from within. Steam generated heats adjacent food solids by conduction. As long as free water is converted to steam, the temperature of the food pieces does not rise over boiling point of water (Potter and Hutckins, 1995). Direct heating is uncontrolled and at high temperature shows higher oxidative stress. The results thus suggest that microwave heating reduces the lipid peroxidation and so can be a better mode of cooking to conserve nutrients.

Most refined oils contain synthetic antioxidants such as BHT (Butylated hydroxy toluene), BHA (Butylated hydroxy anisole) and propyl gallate. So the thermal degradation is expected to be lower in refined oils. But at the same time the raw oils before being subjected to any kind of processing like refining, bleaching, and deodorization, may contain a high amount of natural antioxidants than the refined oils. In this study, the refined oils showed a higher degree of peroxidation

Conclusion

Oils with a higher SFA and lower PUFA content show lower lipid peroxidation. Raw oils are better protected from peroxidation than refined oils probably because of the presence of natural antioxidants. Microwave heating has got a better advantage over normal heating of oils.

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