NFI BULLETIN
Bulletin of the Nutrition Foundation of India
April 1989 Volume 10 Number 2

Fats In Indian Diets

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Fat is an important component of human diet and fulfills several nutritional functions. It is a concentrated source of energy and helps to increase the calorie density of diets. This is particularly important in diets of young children to ensure adequate intake of energy without making the diet bulky. Dietary fat is a carrier of fat-soluble vitamins and facilitates their absorption and mobilisation. Its contribution to flavour and palatability of the diet is important from the point of view of satiety. In recent years, other important physiological roles of dietary fat have been elucidated.

Physiological Role of Essential Fatty Acids (EFA)

Fat is an important source of essential fatty acids (EFA), namely, linoleic acid (LA, 18:2 n-6) and alpha linolenic acid (ALNA, 18:3 n-3). In the body, these are converted to long chain polyunsaturated fatty acids (PUFA) as shown in Figure 1.

PUFA are essential components of the cell membranes. While in all membranes, n-6 PUFA predominate, the retina and the nervous tissue have a greater proportion of n-3 PUFA. The n-3 PUFA have a specific role in vision and the central nervous system. The n-6 and n-3 PUFA are the precursors of a group of biologically active compounds namely, the eicosanoids (prostaglandins, PG; and leukotrienes, LT). Currently, it is believed that a balance of the two EFA influences the functions of the vascular and immune systems. It also influences thrombogenic mechanisms and kidney functions. The EFA play an important role in the transport of cholesterol. Recent studies have emphasised the importance of EFA In foetal growth and early human development.

Fig. 1
Essential Fatty Acids (EFA)

Linoleic acid (LA, 18:2 n-6)	alphalinolenic acid (ALNA, 18:3 n-3)
(Converted to n-6 PUFA)	(Converted to n-3 PUFA)
1. gamma-linolenic (GLA, 18:3 n-6)	1. Eicosapentaenoic (EPA, 20:5 n-3)
2. dihomogamma linolenic acid (DHGLA, 20:3 n-6)	2. docosapentaenoic (DPA, 22:5 n-3)
3. arachidonic acid (AA, 20:4 n-6)	3. docosahexaenoic (DHA, 22:6 n-3)
4. docosapentaenoic (DPA, 22:5 n-6)	

Effect of fatty acids on blood lipids: Alterations in the quality and quantity of fat intake influences the blood lipids, lipoprotein metabolism as well as platelet reactivity in vascular thrombosis[6]. Saturated fatty acids (SFA) increase the blood levels of total and low density lipoproteins (LDL) cholesterol. These are undesirable effects that favour atherogenesis. LA and ALNA have the opposite effect. The available evidence suggests that reduction in blood cholesterol is more easily achieved by reducing dietary SFA than by increasing dietary LA or ALNA. On a weight basis, ALNA has been shown to have a greater cholesterol lowering effect than LA, but dietary levels of LA, above 10 en% are known to lower the levels of high density lipoproteins (HDL) cholesterol also. This latter effect is not desirable as HDL, unlike LDL, cholesterol is antiatherogenic. The n-3 PUFA present in sea foods, reduce the levels of triglycerides in blood. Recent evidence with Mediterranean diets which are rich in oleic acid (OA) suggests that this fatty acid also lowers blood cholesterol but unlike LA, it does not decrease HDL cholesterol (Figure 2).

Fig. 2
Fatty Acids in Atherosclerosis

	SFA	Oleic	n-6	n-3
Blood Choles	↑	↓	↓	↓
HDL Choles	↓	NC	↓	NC
Triglycerides	↑	NC	NC	↓ (LC only)
Platelet Aggregation	↑	NC	↓	↓↓

NC- No Change

Effect of fatty acids on vascular homeostasis: The effects of dietary fatty acids on platelets and the coagula-

tion system are variable. SFA make the platelets more sticky (promote platelet aggregation) and activate the coagulation system. Both these processes favour thrombus formation. The PUFA are converted to eicosanoids in platelet and blood vessels. The eicosanoids have an important role in vascular homeostasis. The net effects of eicosanoids that are formed from n-6 PUFA are antithrombotic. Recent evidence following extensive studies on Eskimos and their diets suggest that the eicosanoids of the "3" series (formed from the n-3 PUFA) have an even greater antithrombotic effect as compared to the eicosanoids of the "2" series (formed from n-6 PUFA). Following these observations, the beneficial effects of fish oil concentrates on atherosclerosis as well as hypertension and diabetes have been established. The therapeutic dose of n-3 fatty acids needed for antiatherogenic and antithrombotic effects are however not without untoward side effects. They increase bleeding time. These fatty acids are susceptible to free radical attack which causes damage to the structure and function of membranes and they increase the requirement of vitamin E. It is important to note that the amounts required for therapeutic effects are different from the minimal requirements. However, criteria for estimating n-3 requirements are lacking.

Fats in Indian Dietaries

Invisible fats: While milk and other foods like eggs, meat, fish, nuts and oil seeds were already known to be important sources of (invisible) fat, recent observations have served to highlight the importance of other components of Indian diets such as cereals, pulses, tubers and vegetables as sources of "invisible" fat (meaning fat which exists as an integral part of the grain). Using the literature values for invisible fat and EFA in various Indian food items, Achaya[1] computed that 10-15 en% (i.e. a level that would provide 10-15 percent of the total energy value of the diet) of invisible fat is present in Indian diets and that this level was adequate to meet the daily LA as well as ALNA requirements.

In a study carried out at the National Institute of Nutrition (NIN)[5], wherein the fatty acid composition of fat present in cereals and pulses was determined by accurate methods of extraction and gas chromatographic analysis, it was found that, on an average, cereals contain three percent and pulses two percent, of invisible fat. On an average, cereals provide 1.3 percent LA, and 0.08 percent ALNA. Pulses provide 1.2 percent LA and 0.28 percent ALNA. Using these figures and the National Nutrition Monitoring Bureau (NNMB) 1979 data on dietary intakes of rural populations, it can be computed that the per caput consumption of invisible fat, LA and ALNA, in the habitual rural Indian dietaries are 16 (range 9-28), 4.8 and 0.35 g respectively. This works out to 7 en% of invisible fat, 2.2 en% of LA, and 0.16 en% of ALNA.

It is, however, not known whether all the invisible fat present in cereals and pulses is biologically available.

Requirements of Visible Fat

The fatty acid composition of commonly used fats and oils in India is given in Table 1. It will be noted that depending on the predominant types of fatty acids, five types of oils can be recognised.

How much "visible" fat is desirable in an average Indian diet? This question is being considered below at three levels: (1) the *minimum level* needed to meet the basic requirement of EFA, in different physiological states; (2) the *desirable level* based on considerations of palatability and satiety; this could be more than the minimum level above but must be less than the "dangerous" level; and (3) the *maximum permissible level* — the ceiling which it will be prudent not to exceed.

Minimum level: On the basis of the current recommendations for total energy (2,400 Cals/consumption unit/day) intakes of Indian population and the FAO/WHO 1977[3] recommendations for LA intake, namely 3 en%, the requirement of LA works out to 8 g/person/day. The invisible fat present in the habitual Indian dietaries can meet approximately two-thirds of this daily LA requirement. To furnish the remaining one-third, the amounts of different vegetable oils required would be any one of the following: 20 g palmolein; 12 g rapeseed or mustard; 7 g groundnut; 5 g sesame; 4 g sunflower; or 3 g safflower. The major sources of edible oils in the country are groundnut and rapeseed; the weighted average of these vegetable oils needed to furnish the recommended intakes of LA would work out to 11 g (4 en%) in an adult man (Table 2). However the needs in pregnancy, lactation and childhood need special consideration.

Pregnancy and lactation: The importance of lipids, n-6 and n-3 PUFA, particularly DHA, in early human development is being increasingly recognised. In man the development of the brain takes place during foetal life and the first two years after birth. The

Table 1
Approximate Fatty Acid Composition of Some Fats (Percentage)

Fats	SFA	OA n-9	LA n-6	LNA n-3	n-6/n-3
High SFA					
Coconut	86	6	1.8	–	–
Ghee (Buffalo)	74	19	2.0	0.9	2.2
Ghee (Cow)	71	25	1.6	0.5	3.2
Vanaspati	76*	19	3.4	–	–
High OA					
Olive	14	72	8	0.7	11.4
Moderate OA and LA					
Palmolein	48	38	9	0.3	30
Groundnut	19	47	28	0.8	35
High LA					
Sesame	15	39	40	0.5	80
Corn	13	25	57	0.8	71
Sunflower	11	34	49	0.3	163
Safflower	9	12	73	0.5	146
High LNA					
Rape/Mustard	4	11	13	8.6	1.5
Soyabean	15	23	51	7	7.3

* *Includes trans fatty acids*

requirements of fat and EFA are therefore high during pregnancy and lactation. According to FAO/WHO, the minimum requirements for LA in pregnancy and lactation are 4.5 and 6 en% respectively. The present computations show that the invisible fat of cereals, pulses and milk in Indian dietaries may meet 42 percent and 30 percent of the total LA requirements in pregnancy and lactation. To furnish the additional amount of LA to meet the total requirements of LA, the diets of pregnant and lactating women would have to provide 30 g (12 en%) and 45 g (17 en%) of vegetable oil respectively (Table 2).

Table 2
Suggested Minimum Intakes of Vegetable Oil to Furnish the Daily LA Requirement

	Daily LA requirement En %	% requirement met from invisible fat	Vegetable oil needed En %
Man	3	66	4 (11 g)
Woman	3	66	4 (9 g)
Pregnancy	4.5	42	12 (30 g)
Lactation	6	30	17 (45 g)
Children:			
1-6 yrs	3	60	14 (23 g)
7-12 yrs	3	63	9 (21 g)

Computation based on LA content of cereals, pulses and milk in rural diets

Children: In fulfilling the energy needs of children through cereal pulse diets, bulk would be a problem. In order to overcome this, it has been suggested that their diets should contain a minimum of 20-25 percent total fat calories[3,14]. In well-to-do Indian preschool children with satisfactory growth, the mean intake of fats and oils is 14 en%[11]. This level of oil intake appears to be adequate to ensure both energy density of the diet and meet the daily LA requirement of young children.

Desirable Level of Visible Fat

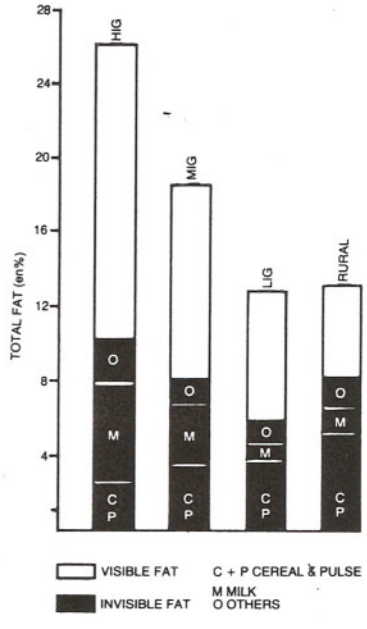
The intakes of vegetable oil for an adult man — 11 g (4 en%) — suggested above is an estimate based on the *minimum daily requirement* of LA. The FAO/WHO 1977 suggested 15 percent total fat calories to be *optimal* for all age groups. To provide 15 percent total fat calories, 22 g (8 en%) vegetable oil would have to be provided. A level of 22 g visible fat/person/day may be a *desirable* level. This level of vegetable oil will not only provide adequate LA and calorie density to the diet but it will also be *practicable* from the point of view of *palatability and satiety.*

Dietary fat in different income groups: Visible fat in the rural poor dietary is predominantly vegetable oil; animal fat is negligible. The average intakes of vegetable oil in the rural population range between 2-19 g, average 10 g (NNMB, 1979) which is very close to the figure for *minimum vegetable oil requirements* for adults arrived at from the computations above.

From available data on fat composition of foods, and the NNMB 1982 urban data on food intakes of various income groups, the total contents of diets, in four Indian states have been calculated, making certain assumptions, which may need revision as more data become available (Figure 3). The average figures arrived at on the basis of these assumptions indicate that diets of high income group (HIG) contribute 10 en% of invisible fat. Diets of other income groups contain lower amounts (middle income group (MIG) 8, low income group (LIG) 6, and rural 8 en%). Income-related differences are seen in the HIG, the invisible fat from cereals and pulses being about half the quantity (2.6 en%) present in the diets of the rural poor (5.3 en%). From milk however, it is about four folds higher (HIG 5 en%, rural 1.3 en%). When the figure for visible fat consumed is added to the invisible fat intake the total fat calories in the various income groups works out to 26 percent in HIG, 19 percent in MIG and 13 percent in LIG and the rural population. In each income group about half of the total fat is invisible (38-53 percent).

Upper limits of fat intake: It is generally agreed that total fat calories in human diets should not exceed 30 en% or even less in sedentary individuals[4,8]. Since the diets of HIG provide 10 en% of invisible fat, the intake of visible fat should not exceed 15-20 en%. For an adult man who consumes 2,400 calories, this works out to a figure of 40-55 g/day. In earlier reviews, 50 g[1] and 40 g[7] have been suggested as upper limits for visible fat.

Fig. 3
Visible and Invisible Fat in Diets of Different Income Groups



HIG: High Income Group; MIG: Middle Income Group; LIG: Low Income Group.

Quality of Fat

It is apparently not enough to ensure an adequate overall intake of EFA. Recent studies indicate that it is important to ensure an optimal ratio of n-6/n-3 fatty acids in the diet.

The intake levels of n-6 and n-3 fatty acids should be considered together and not in isolation, since both of them compete for the same enzymes. The minimum requirement of LA is 3 en% and from the limited information available, the requirement of ALNA is believed to be between 0.3-1 en%[2,9,10]. It is considered desirable to have a ratio of n-6/n-3 fatty acids around 5-10; ratios above 50 lead to tissue depletion of DHA (22:6 n-3) in experimental animals and may therefore be considered definitely undeniable. But what about ratios between five and 50; is there a wide range of normalcy of n-6/n-3 fatty acid ratios; or is it that intakes of fat in proportions in which n-6/n-3 fatty acid ratios exceed 10 over prolonged periods have any untoward health effects?[12,13] This is an area for further research.

Ratio of n-6/n-3 fatty acid: Using the above criterion, computations of fatty acid intakes in various income groups with different vegetable oils as the major source of fat show that the ratio of n-6/n-3 fatty acids with rapeseed/mustard, soyabean and palmolein are in the desirable range in HIG and MIG of our population (Table 3). With safflower oil, the ratio in all groups is 30 and above. It therefore appears that oils containing very high amounts of LA like safflower oil are likely to distort the ratio unfavourably.

Since the n-3 fatty acids have an essential role in the development of the retinal and nervous tissue, it is particularly important to ensure adequate intakes of n-3 fatty acids in pregnant and lactating women. Human milk contains the parent EFA (LA and ALNA) 4-5 en% as well as the long chain n-6 and n-3 PUFA (1 en%). The ratio of n-6/n-3 PUFA in human milk is around 4:1 to 10:1[13]. It is widely accepted that breast milk fatty acid composition should be used as a guideline for the preparation of infant formulae. The long chain PUFA are biologically more potent than is the parent EFA. It has been calculated that human infant formulae based on parent EFA alone may not satisfy the infant's high PUFA requirements. It may be therefore important to incorporate in infant formulae some amounts of long chain n-6 and n-3 PUFA so as to match the quality of fat with that of human milk. Studies are needed on breast milk fatty acid composition of Indian mothers of different income groups at various stages of lactation.

Table 3
Dietary Ratio of LA/ALNA (n-6/n-3) With Various Edible Oils in Different Income Groups

	HIG	MIG	LIG	Rural
Invisible fat intake (g)	28.6	20	12.8	18.6
Visibile fat intake (g)	43	27	16	11
Safflower oil	39.6	32.6	33.9	30.0
Sesame oil	32.4	26.4	26.6	24.5
Groundnut oil	22.7	19.3	20.1	21.3
Palmolein	10.0	9.7	11.5	14.9
Soyabean oil	9.5	9.6	10.3	11.9
Mustard oil	3.7	4.2	4.9	7.5

Concluding Comments

Dietary fat was so far considered to be an important nutrient as a mere concentrated source of energy. However, recent research on fat as a nutrient definitely indicates that both the quality and quantity of fat have important repercussions on health and disease. From the above discussion the following points emerge:

- Among the visible fats each has its own merits and demerits.
- For an adult man consuming 2,400 calories, the minimum requirement of total fat is 40 g and LA is 8 g.
- In the habitual rural diets about half of the total fat needed is furnished from invisible fat and this provides two-thirds of the daily LA requirement.
- To fulfill the total LA requirement, the suggested minimum intakes of vegetable oil for different physiological groups is: adults 11 g, children 23 g, pregnant women 30 g and lactating women 45 g.
- The upper limits of daily visible fat intake should not exceed 55 g. In dietaries in which overall fat intake is around the upper limits, it would be best to restrict the intake of butter, hydrogenated oils and coconut oil to the minimum.
- Saturated fats and trans fatty acids in hydrogenated vegetable oils tend to increase the blood cholesterol and are thrombogenic when the total dietary intake of SFA exceeds 8-10 en%.
- Commonly consumed groundnut oil provides adequate levels of LA but has approximately 5 percent of long chain SFA. In comparison, sesame oil has somewhat lower levels of SFA and higher levels of LA, for this reason, sesame oil may be considered to be more desirable.
- Rapeseed/mustard oil has the demerit of containing high levels of erucic acid which has been shown to cause lipidosis in experimental animals. However, due to its high ALNA content, the ratio of n-6/n-3 fatty acids in this oil is in the desirable range. Indian diets containing this oil as the major source of visible fat furnish optimal ratio of n-6/n-3 fatty acids.
- Palmolein has 50 percent SFA (mainly palmitic acid). In spite of this relatively high level of saturated fat, palmolein does not raise the levels of blood cholesterol. Recent studies indicated that palm oil inhibits arterial thrombosis, does not promote atherosclerosis, and has no effect on blood pressure. In addition, it has high levels of vitamin E (tocopherols and tocotrienols). Also the ratio of n-6/n-3 fatty acids is in the desirable range.
- Safflower oil which provides high amount of LA has been widely publicised for its cholesterol lowering properties. However, if this oil is the major source of visible fat, the ratio of n-6/n-3 fatty acids will turn out to be higher than the currently believed desirable ratio of less than 10.
- Soyabean oil has balanced amounts of different fatty acids, but because of its characteristic smell and short shelf life, it is not widely accepted. To overcome this, it is partially or completely hydrogenated but this process reduces the n-6 and n-3 fatty acids and increases the level of SFA and trans fatty acids.
- Therapeutic use of fish oil is currently advocated. It has been suggested that inclusion of 100 g of fish twice in a week