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Fatty Acids In India – Current Research And Government Policies

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India, like most Asian countries, is now in a state of developmental transition. Old problems are fortunately receding; but "development" being somewhat of a two-edged weapon, new problems are emerging. India, like other developing countries, is therefore facing the double burden of old problems, which are not yet fully solved and new emerging problems, which need to be combated. While a considerable proportion of the population is still below the poverty line – a proportion fortunately diminishing – there is now a rapidly emerging urban middle class whose number is estimated to exceed 250 millions[1]. The nutritional problems which confront the poor, on the one hand, and the affluent, on the other, and consequently, the problems with respect to their respective fat requirements, are totally different. Both ends of the socio-economic spectrum require to be addressed.

In the case of the poor, the attempt has to be towards increasing the fat intake, so as to improve the calorie density of the cereal-based diets and to ensure adequate intake of essential fatty acids. In the case of the affluent sections, however, the attempt must be to ensure that the quantity of fat intake does not exceed desirable limits and the quality is such as to provide for an adequate balance of the essential fatty acids.

Indian diets are predominantly cereal-based[2]. The dietary fat intake, in a considerable proportion of the population, is low in comparison to the levels of intake in Europe and America. Fat intakes in India are highly income-dependent and, for this reason, are highly skewed[3,4]. While in Europe and America, the major concern is to restrict the dietary fat intake, in India, among the poor sections of the population, the concern is for augmentation of fat intake, so as to increase the calorie density of predominantly cereal-based diets. This is especially the case with infants and children, where even with increase in the frequency of feeding of a predominantly cereal-based diet, energy requirements cannot be met adequately[5]. Even among the affluent sections of India, the fat intake is generally not of the order seen in Europe and America. Thus, the average per capita consumption of fat in India is 8 kg/year as compared to 16 kg/year in the world as a whole, and more than 40 kg/year in the developed countries[6]. A survey carried out in 10 Indian states showed that the visible fat intake was below 10 gms daily in the rural population[3]. On the other hand, in the urban middle class, the visible fat intake ranged from 30-72 g/day[3,4].

RESEARCH

Research on fats in India has covered the following areas:

- A review of the actual intakes of fats in the diets in different sections of the population;
- The sources of dietary fats and their fatty acid composition;
- "Invisible fats" and their food sources;
- Fatty acid requirements;
- Identification of appropriate blends of vegetable oils in order to ensure essential fatty acid balance;
- Development of erucic acid-free mustard oil;
- More recently, the assessment of the role of n-3 fatty acids in optimising the lipid profile and in combating insulin resistance and abdominal obesity; and
- The role of essential fatty acids in combating low birth-weight deliveries and the pregnancy outcome in poor segments of the population.

GOVERNMENT POLICIES

Government policies with respect to dietary fats at the macro level (as against household levels) are largely directed towards augmenting the production of foods rich in fats. In the days of the Green Revolution, the emphasis was on fighting hunger and famine, and therefore agricultural policies were largely directed towards increasing the production of cereal foods such as rice and wheat. The need for diversification of food pro-

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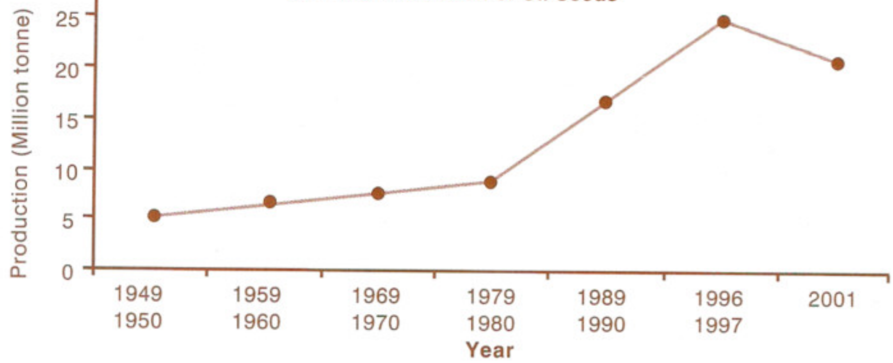
TABLE 1
Production of Milk, Fish and Oilseeds (Million Tonnes) – India

	1950-51	1980-81	1990-91	1996-97	1999-2000
Milk	–	35.8*	53.9	68.6	79.3
Fish	0.7	2.44	3.84	5.35	5.65
Oilseeds	5.16	9.37	18.61	24.96	21.00

** Refers to milk production in 1982-83*

FIGURE 1
All India Production of Oil Seeds



duction is now recognised and efforts are directed towards augmenting production of oil seeds, milk, and fish. Table 1[7] shows the increase in the production of oilseed, milk and fish in recent years. India is today the world's leading milk producer.

It will be noted that there has been a steady increase in the production of oil seeds, the highest being 25 million tonnes in 1996-97 (Figure 1). India is the world's largest importer of edible oil, but is also a main oil meal exporter. For example, soy meal exports are expected to reach 2.2 million tonnes in the current year. In order to further augment oil seed production, the Government of India in its recent budget has further raised the "minimum support price" for oil seeds. This measure is in the nature of a subsidy and incentive for oil seed production.

TABLE 2
Vegetable Fats in India

Traditional Sources	Newer Sources
Groundnut oil – West and South	Rice bran oil
Coconut oil – Kerala (South)	Palmolein
Sesame – South	Soya oil
Mustard oil – North and East	
Safflower oil – Karnataka (South)	
Vanaspati – Lower middle class	
Ghee – Affluent	

While the augmentation of oil seed production is to be welcomed, the fact that nutritionally valuable oil meals are being exported is not a favourable development, at least from the national nutritional development point of view. A mere increase in the oilseed production at the macro level cannot automatically ensure adequate intake of fats at the levels of poor households. Income-generating anti-poverty programmes have to be intensified. Several such programmes are ongoing, but the eradication of poverty is apparently a slow process.

SOURCES OF FATS IN INDIAN DIETS

Since a considerable proportion of the population of India is vegetarian, the main sources of fats are vegetable oils, milk and milk products. The sources of fat in Indian diets can be broadly divided into "visible" and "invisible" fats.

Visible fats: Visible fats are the vegetable oils used as cooking fat. There are wide regional preferences in the quantity and the type of fat consumed in different parts of the country[8]. The list of vegetable fats that are in common use in different parts of the country is indicated in Table 2. Visible fats are largely triglycerides, the common fatty acids therein being palmitic acid, stearic acid, oleic acid and linoleic acid. The composition of fatty acids in different fats varies (Table 3).

Invisible fats: Most foods (plant and animal) contain fat as an integral component of their cells. Earlier estimations of fat in Indian diets were based on the weighment of ether extracts[9], which remove only the free lipids and not the structurally tightly- bound lipids. These later can be extracted only after acid hydrolysis with chloroform and methanol mixture. Accurate estimates of total fats and individual fatty acids in Indian diets have now been carried out by Ghafoorunissa (Table 4,5)[10-12].

It will be seen that cereals and millets, which are the bulk items in Indian diets, contribute substantially to the fat intake Thus a daily consumption of 300-500 gms of cereals or millets alone could provide 8-10 gms of invisible fat[13]. Invisible fats of plant foods are good sources of oleic acid, linoleic acid (LA) and α linolenic acid (ALNA). While in most foods, LA predominates, legumes, green leafy vegetables and spices contain high proportion of ALNA[11,12].

Dietary fat requirement in Indian subjects: Ghafoorunissa[11] has estimated that, on the basis of the recommendations of the Food and Agriculture Organisation[14], and taking into account the invisible fats contained in Indian diets, an Indian adult would require at least 20 gm of visible fat as oil, as against 10 gm which is the current intake of most poor rural populations. In the case of pregnant and lactating women, the requirements of total fats and essential fatty acids are higher. The invisible fat of cereals and pulses present in usual Indian diets can provide only 30-40 per cent of the energy requirement in pregnancy and lactation. It has, therefore, been suggested that the intake of visible fats in pregnant and lactating women must be 30 gm and 45 gm, respectively. In the case of children, the energy density of diets must be higher than that in the case of adults. It has been suggested that children's diet should contain 25 energy per cent which would work out to be 25 gm of visible fat daily[11,15].

TABLE 3 Approximate Fatty Acid Composition of Visible Fats (gm/100gm)	SFA	MUFA	LA	ALNA	LA/ALNA
Coconut	89	7	2	<0.5	4
Vanaspati	24	19	3	<0.5	6
Red palm(raw)	50	40	9	<0.5	18
Groundnut	24	50	25	<0.5	50
Rape seed/mustard	8	14	12	10	1
Sesame	15	42	42	1	42
Sunflower	13	27	60	<0.5	120
Safflower	13	17	70	<0.5	140
Soyabean	15	27	53	5	11

Ensuring the quality of fats in Indian diets: Ghafoorunissa had also shown that no single vegetable oil furnishes both ideal PUFA-SFA and ideal LA/ALNA ratios (n-6: n-3)[14-18]. Thus oils such as safflower oil, sunflower oil and soyabean oil furnish higher than ideal PUFA-SFA ratio, but provide correct LA-ALNA ratio. Mustard oil provides considerable amounts of erucic acid, which is not desirable. Erucic acid, the LC MUFA, present in mustard oil is shown to be undesirable since it induces lipidosis and fibrosis in experimental animals[19]. Erucic acid-free mustard oil is now available in Sweden and Canada, but the manufacture of such erucic-acid-free mustard oil is still in an experimental stage in India.

Coconut oil furnishes low PUFA-SFA ratio and inadequate levels of EFA. Hydrogenated oils increase the intake of trans-fatty acids, which are now considered undesirable. In view of these findings, a complete dependence on just one vegetable oil, as the sole source of fat is now considered undesirable.

As has been pointed out earlier, considerable proportions of Indian populations are vegetarians and do not even eat fish. Under these circumstances, in order to ensure adequate intake of long chain n-3 fatty acids, vegetarians have largely to depend on plant foods, which are rich in ALNA. While most of the vegetable oils contain LA only, oils extracted from soya bean, rapeseed, mustard and rice bran have both LA and ALNA, and the human body can synthesise n-3 PUFA from ALNA. In India there is a wide choice of plant foods, which are good sources of ALNA. Pulses and legumes, for example, provide more ALNA than cereals and millets. Spices such as fenugreek seeds and mustard seeds are rich sources of ALNA[8,11]. The use of green leafy vegetables will not only increase ALNA but also confer other benefits. Indian studies have shown that vegetable oils containing ALNA are as efficient as fish oils containing LC PUFA with respect to hyperlipidemic and antithrombotic effects[18].

Since the requirement of ALNA increases with increase in LA intake, it is essential to maintain a balance between the two. This can be done by using either of the following: oils with moderate levels of LA (groundnut, ricebran, sesame) or oils with high amount of LA (safflower, sunflower, cotton seed) in combination with palm oil or mustard oil to increase the ALNA. This will also decrease the overall intake of erucic acid present in mustard oil. Apart from fatty acids, vegetable oils contain various tocols (tocopherols and tocotrienols). For example, the total tocol content of palm oil is 1,000 mg/100 gm and of rice bran oil is 500 mg/100gm[20]. These tocols have hypocholesterolemic, antioxidant, and antithrombotic and anticarcinogenic properties[20].

NEWER SOURCES OF VEGETABLE OILS

In recent years, apart from attempts to develop a technology for the production of erucic acid-free mustard oil, there have also been major attempts at identifying and propagating new sources of vegetable oils. The three major oils that may be mentioned in this context are rice bran oil, palmolein and soya oil. A brief account of the efforts with respect to these three vegetable fat sources

TABLE 4
Invisible Fat and Fatty Acids in Cereals and Pulses in gm/100 gm of Food

Food	Fat	SFA	MUFA	LA	ALNA	LA/ALNA
Cereals						
Rice	1.7	0.4	0.4	0.5	0.01	41
Wheat	2.9	0.5	0.3	1.1	0.17	6
Maize	4.8	0.8	1.1	2.2	0.05	47
Jowar	3.3	0.6	1.0	1.5	0.05	32
Ragi	1.5	0.3	0.7	0.3	0.05	5
Bajra	5.5	1.2	1.2	2.2	0.13	17
Legumes						
Black gram	1.7	0.3	0.2	0.1	0.7	0.2
Rajma	2.2	0.4	0.2	0.5	0.7	0.7
Cow pea	2.9	0.8	0.2	0.8	0.5	1.7
Green gram	1.7	0.5	0.05	0.6	0.2	3
Red gram	2.2	0.5	0.1	1.0	0.1	8
Lentil	2.0	0.3	0.4	0.8	0.16	5
Bengal gram	6.0	0.7	1.7	1.2	2.7	1.8
Peas	2.1	0.3	0.4	0.8	0.15	5
Soya bean	20	2.8	5.4	10.4	1.4	7

SFA: Saturated fatty acid *MUFA: Monounsaturated fatty acid* *LA: Linoleic acid*
ALNA: Alpha-linolenic acid

TABLE 5
Invisible Fat and Fatty Acids in Vegetables, Condiments and Nuts and Oil Seeds in gm/100 gm of Food

Food	Fat	SFA	MUFA	LA	ALNA	LA/ALNA
Vegetables						
Green leafy vegetables	0.4	0.09	0.025	0.04	0.15	0.3
Others	0.2	0.05	0.016	0.06	0.03	2
Potato/yam	0.6	0.15	0.15	0.08	0.06	5
Condiments						
Dry chillies	17	2.5	1.9	9.1	0.26	35
Cumin seeds	9	0.4	4.7	2.1	0.48	4
Coriander seeds	20	1.7	12.5	3.0	0.02	129
Fenugreek seeds	10	1.2	1.5	3.4	1.9	1.8
Nuts and oil seeds						
Coconut	40	36	3.2	0.6	–	–
Groundnut	40	8.8	21	10	0.2	50
Sesame	40	6.0	18	16	0.4	40
Mustard	40	2.0	5	5	3.5	1.4
Almond	56	25	19	8	0.2	40
Cashew nut	50	10	29	9	0.3	30

SFA: Saturated fatty acid MUFA: Monounsaturated fatty acid LA: Linoleic acid
ALNA: Alpha-linolenic acid

is given below.

Rice bran oil: Rice, along with wheat, has been the major staple of the Indian diet. Milling of paddy to obtain edible rice grains yields two byproducts of economic and nutritional importance, namely paddy husk and rice bran. Rice bran, unlike paddy husk, can serve as an animal feed, as a human food supplement and as a valuable source of edible oil. India, like China, has vast rice bran potential. Rice bran that has been heat stabilised to inactivate the lipase is a good source of edible oil with nutrition and health promoting potential. Rice bran oil has a desirable fatty acid profile with 35 per cent LA and 2 per cent ALNA acid[21].

The peculiar feature of rice bran oil, as compared to other common vegetable oils, is its high content (4-5 per cent) of unsaponifiable matter[22]. The high unsaponifiable matter in rice bran oil is not only safe for human consumption but also contains valuable phytochemicals with potential for reducing blood cholesterol and guarding against the risk of heart disease. This potential of rice bran oil in protecting against high blood cholesterol has been studied and exploited only during the past two decades [23-25]. Rice bran oil, its unsaponifiable matter and its components, Phytosterols, oryzanol and tocotrienol, have been shown to be more efficient in reducing blood cholesterol than other oils with comparable LA (such as groundnut oil), both on experimental animals and human subjects[26].

Recently, it has been reported by Sugano[27] that blending rice bran oil with safflower oil in the ratio of 7:3, wt/wt, magnified the hypocholesterolmic effect. Palm oil is another edible oil which, when blended with rice bran oil, could enhance the latter's effect of reducing the risk of heart disease. A blend of rice bran oil with palm oil in the proportion of 3:1 can yield a blend with SFA, MUFA and PUFA ratio of 1.0:5.0:1.0, which is the most desirable ratio in an edible oil for preventing heart disease according to the American Heart Association and the Japanese Ministry of Health and Welfare.

Palm oil: Palm oil cultivation, which is prevalent in Indonesia and Malaysia, is also now being promoted and undertaken in several parts of India, especially South India, where climatic conditions are favourable for such production. Recognising that oil palm, a perennial tree, can produce three to four times more oil than the annual yield of conventional oil seeds, promotion of palm oil production through palm oil cultivation has been undertaken in several parts of India both by private and government agencies[28].

Most vegetable oils are extracted from oilseeds, whereas palm oil is derived from the fruit of the oil palm. Red palm oil contains small amounts of free fatty acids, phosphatides, moisture, carotenes and tocols (tocopherol and tocotrienols). During refining of red palm oil, all these compounds except tocols are removed and, therefore, a refined bleached deodourised palm oil has a pale colour like other refined oils, and is a semi-solid at room temperature and has a good shelf life. Palmolein is the liquid fraction of palm oil[29].

The major difference between palm oil and other oils is its higher proportion of palmitic acid (16:0). Palm oil, palm stearin and palmolein share the same fatty acids, namely palmitic, oleic (18:1) and linoleic (18:2 n-6)[29]. Like most vegetable oils, red palm oil contains about 1.5 per cent of unsaponifiable matter, which includes the sterols, tocols (tocopherols and tocotrienols) and carotenes. In palm oil, the tocotrienols constitute two-thirds of the total tocols[29].

Studies[30-33] have shown that palm oil does not behave like a saturated fat in its effect on blood cholesterol and blood clotting as might be anticipated from its fatty acid composition. The deviant nutritional properties of palm oil as compared to other saturated fats are attributed to the following:

- Palmitic acid, which is less hypercholesterolemic as compared to lauric and myristic acids, is the major SFA in palm oil.

- Like other vegetable oils palm oil is rich in oleic acid, which is hypocholesterolemic as compared to the SFA.

- It has been shown that palmitic acid and stearic acid are more hypercholesterolemic when present in β position of the triglyceride. In palm oil palmitic acid is predominantly present in the α position.

- Palm oil is also rich in vitamin E,

which confers natural stability against oxidative deterioration. The vitamin E in palm oil is, furthermore, characterised by a preponderance of tocotrienols (over 70 per cent), rather than tocopherols (30 per cent)[34]. The tocotrienols have now been shown to inhibit cholesterol synthesis in the liver and possibly to inhibit tumour growth in experimental animals[35].

Thus, palm oil has several nutritional benefits, which clearly distinguish it from other saturated fats, and the low cost of palm oil will be an added advantage for meeting the needs of fats and oils by the growing Indian population. Studies at the National Institute of Nutrition[13] in India have demonstrated that substitution of groundnut oil (one of the major oils used in India) with palmolein in the customary cereal-pulse based diet which has 2 energy per cent linoleic acid (from cereals and pulses) will not have any adverse effects on the linoleic acid status of the population. It is estimated that use of palm oil along with any other vegetable oil(s) will favourably shift the dietary PUFA/SFA and n-6/n-3 ratios closer to the recommended range[36] and provide an additional advantage because of the antioxidant properties of tocopherols and tocotrienols.

Soya oil: Soya oil, which is in wider use in other parts of Asia, is a relative new comer in India. Presently the USA, Brazil, China, Japan and Argentina together account for 87 per cent of the world's soyabean production. Soya bean has drawn considerable attention from nutritionists in Asia because it is less expensive to grow and yet rich in calories, proteins and fats[37]. Soya bean which did not even exist as an oil seed crop in India before the 1960s is now the third most important oil seed, covering an area of more than 2.4 million hectares. About 30 per cent of the total area is in Madhya Pradesh, which is now called the 'Soya Bean State'. The utilisation of this crop is as follows.

	Million Tonnes
Soya production	5.7
Soya oil	1.6
Soya meal	4.1
Export of meal	3.0
Domestic use	1.1

Soya bean is unique among oil seeds. Soya beans have high oil content, higher than other pulses[38]. The quality of soya oil surpasses that of other oils. It contains 20 per cent fat and has a large content of polyunsaturated fatty acids, which are anticholesteric. Low in saturated fat, soya-bean oil is an excellent source of essential fatty acids, such as LA (50 per cent) and ALNA (7 per cent) as well as oleic acid (24 per cent) and tocopherol (vitamin E).

This makes it a high quality vegetable oil, with cholesterol lowering function. A moderate consumption within the recommended dietary fatintake levels provides optimum health benefits.

Omega-3 fatty acids: Two major research programmes on n-3 fatty acids, which are currently ongoing at the Nutrition Foundation of India, New Delhi, are:

- Study on the efficacy of supplementation with n-3 fatty acid in abdominal obesity.
- Feasible strategies for combating low-birth weights and intra-uterine growth retardation.

The results of these studies will be reported separately.

In earlier years, carbohydrates and proteins held the centre stage of nutrition research. In later years, attention shifted to micronutrients. The deleterious effects of fat intake, rather than the beneficial effects, were being highlighted because of the experience of the developed countries, where high fat diets were associated with chronic degenerative diseases. It is only in later years that the importance of the essential fatty acids in human health and nutrition was recognised. With this recognition, there has been a growing intensive research on fats and especially on essential fatty acids. The studies mentioned above are a reflection of such increasing interest in fat nutrition.

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