REVIEW ARTICLE

Scientific basis of fat requirement for Indians and recent trends in CVD

S Ahamed Ibrahim

Department of Lipid Chemistry, National Institute of Nutrition, Hyderabad

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Corresponding Author

Address for Correspondence: S Ahamed Ibrahim, Department of Lipid Chemistry, National Institute of Nutrition, Hyderabad

E Mail ID: ahamed65@yahoo.co.in

Citation

Ibrahim SA. Scientific basis of fat requirement for Indians and recent trends in CVD. Indian J Comm Health. 2014;26, Suppl S1:54-58

Source of Funding : Nil **Conflict of Interest:** None declared

Abstract

Dietary fats have several roles such as provision of metabolic energy, fat soluble vitamins and essential fatty acids (linoleic, LA and α-linolenic, ALNA). Fats improve texture and palatability and have a satiety role. LA and ALNA and their long-chain polyunstaturated fatty acids (LC n-6 PUFA and LC n-3 PUFA respectively) are important structural membrane components and therefore essential for formation of new tissues. LC n-3 PUFA have specific role in vision and nervous system. Both n-6 and n-3 PUFA are essential for fetal and early infant growth and development and nervous tissue development. The absolute levels and ratio of n-6 and n-3 PUFA in membrane affect a wide range of physiological processes either directly or through eicosanoids. The individual components of fats affect the risk of diet - related chronic diseases through the atherogenic effects of plasma lipids, insulin resistance, thrombosis, endothelial dysfunction as well as pathways of inflammation. The chain length/geometric configuration of double bonds and position of saturated (SFA), mono unsaturated (MUFA) or PUFA on glycerol backbone (triglyceride structure) modify the nutritional and metabolic effects of dietary fats. The non-glyceride components present in the vegetable oils have hypocholesterolemic and antioxidant effects. Several lines of evidence have documented that restrictions in SFA and cholesterol, negligible intake of trans fatty acids (TFA) on the one hand and preference for more than one type of vegetable oil (to ensure adequate absolute intakes of LA, ALNA and their ratio), adding n-3 PUFA from fish or plant sources, and ensuring moderate intake of total fat in the diet substantially reduces the risk of diet-related chronic diseases. Studies were done at National Institute of Nutrition on intake of individual fatty acids, the pro/anti-athero-thrombogenic effects of different types of visible fats in Indian adults, insulin sensitivity and the antioxidant properties of unique non glyceride components of some of the commonly consumed edible oils. From the data generated, the quantity and combination of visible fats, foods to be preferred so as to increase 'healthy fats', foods to be avoided/restricted to reduce 'unhealthy fats' have been worked out. Ensuring optimal intake of fat (quantity and quality) throughout life-span may contribute to the widely prevalent nutrition and health problems in India (low birth weight, chronic energy deficiency and diet-related chronic diseases).

The rapid increase in prevalence of diet-related chronic diseases including type 2 diabetes, obesity and hypertension worldwide possess an immense public health and medical challenge for the implementation of successful preventive and treatment strategies. Insulin resistance is an important risk factor for type 2 diabetes and is often associated with other metabolic abnormalities and cardiovascular risk factors. Moreover it is also an important risk factor for cardiovascular diseases (CVD). Obesity when associated with abdominal adiposity is an important determinant of insulin resistance and represents the most important risk factor for type 2 diabetes and metabolic syndrome. The explanation for the explosion of the epidemic of chronic diseases involve changes in dietary habits and or / increasing the sedentary life style, since our genetic pool remained stable. Poor control of the life style risk factors results in metabolic dysregulation, endothelial dysfunction and increased adiposity which in turn together lead to dyslipidemia, hypertension, type 2 diabetes, systemic inflammation, thrombosis and risk

of arrhythmia (1). The ultimate result is sub clinical and then clinically apparent CVD including coronary heart disease (CHD), cardiac arrhythmia, heart failure and stroke. The best way of preventing chronic diseases is to take a balanced diet that does not provide excess calories along with regular physical activity. Over the past few decades evidences that has accumulated suggests that both the quality and quantity of dietary fat is associated with pathogenesis of several diet-related chronic diseases (2).

Key Words

Fatty acids; tocotrienols; MUFA; PUFA

Introduction

Chemical composition of fats

Dietary fats/oils consist of two fractions: 1) glyceride fraction which accounts for 95 - 99% of fatty acids and 2) the non-glyceride fraction (1-4%) which constitutes the minor components such as tocopherols, tocotrienols, lignans, phytosterols, oryzanol etc. Most of these minor components are potent antioxidants and having hypercholesterolemic properties. The fatty acids present in fats/oils can be classified into saturated fatty acids (SFA), mono unsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA). MUFA can be of two types namely cis & trans. MUFA present in vegetable oils are in the cis form, whereas the trans form is formed during industrial hydrogenation of vegetable oils. In Indian diets trans fatty acids (TFA) are derived from vanaspati (partially hydrogenated vegetable oils, PHVO). In addition, small amount of TFAs are present in ruminant fats (butter, cheese, ghee etc) by bacterial hydrogenation of PUFA in the rumen of ruminants. PUFA comprise linoleic acid (LA, n-6) & α-linolenic acid (ALA, n-3) and their respective LC PUFAs namely arachidonic acid (AA, LC n-6 PUFA) and eicosapentaenoic acid (EPA, LC n-3 PUFA) and docosapentaenoic acid (DHA, LC n-3 PUFA).

PUFA metabolism

LA & ALA undergoes series of delicate chain elongation and desaturation reactions in our body resulting in formation of LC n-6 PUFA namely AA and long chain n-3 PUFA namely EPA and DHA. LA is present in most of the vegetable oils. Sunflower and safflower oil are the richest sources of LA, whereas ALA is present only in selected oils such as soybean, mustard and canola oil. EPA & DHA are present only in fish and fish oil. Both LA & ALA compete with each other for the same desaturase enzyme which converts them to their respective biologically active long chain derivatives. The levels of n-6 & n-3 PUFA in membranes and their ratios affect a range of biological processes either directly or via production of eicosanoids and leukotrienes. In response to various stimuli the LC derivatives of n-6 & n-3 PUFA competes for cyclooxygenase and lipoxygenase enzyme systems and gets converted into eicosonoids of "2" & "3" series respectively. The eicosonoids have important bio regulatory functions. The eicosonoids derived from long chain n-6 PUFA are proinflammatory and atherothromobogenic compare to those derived from long chain n-3 PUFA (3). Hence balanced intake of n-6 & n-3 PUFA is essential for optimal health benefits.

Dietary fats and risk factors of diet related chronic diseases

Recommendations on fat intake with regard to cardiovascular health have been refined over the years (4,5). Earlier recommendations for the prevention of CHD have given emphasis for the reduction of total fat in the diet through substitution of carbohydrate for fat. However recent studies clearly established that higher fat intake is not necessarily bad provided the energy balance is maintained in relation to carbohydrate and protein intake and the dietary fat should be low in SFA & TFA and high in unsaturated fatty acids. Hence choosing a right type of fat is more important than reducing the amount of fat. Current evidence suggests that relative to isocaloric amount of carbohydrates, SFA increase but PUFA (LA) lower LDL cholesterol, the effects of MUFA (oleic acid) is in between that of carbohydrates and PUFA. The hypercholesterolemic effect of SFA are attributed to lauric (C12:0), myristic (C14:0) and palmitic (C16:0) acids. Dietary cholesterol increases the hypercholesterolemic effect of SFA. Stearic acid (C18:0) does not increase the blood cholesterol levels possibly because it is rapidly metabolized to oleic acid. Substitution of part of carbohydrate with MUFA increases HDL cholesterol in normal and hyperlipidemic subjects. This substitution also improves glucose tolerance and insulin sensitivity in diabetic patients. Moreover MUFA renders LDL resistant to oxidative

modification. In addition to vegetable oils, nuts and avocados also contain high levels of MUFA. Several epidemiological studies have documented that nut consumption reduces the relative risk of CHD (6). Controlled feeding trails showed that MUFA from nuts lower LDL cholesterol and increase HDL cholesterol to a greater extent than MUFA from oils. In addition to MUFA and PUFA, other components of nuts such as soluble fiber, vitamins, trace elements and good quality protein may contribute to the beneficial effects of nuts. Epidemiological studies have shown a strong positive association between TFA intake and CHD risk through multiple mechanisms (7). Unlike SFA which increases LDL cholesterol, TFA not only increases LDL cholesterol but also decreases HDL cholesterol suggesting that TFA are more atherogenic than SFA. Moreover TFA increases lipoprotein (a) (an independent CHD risk factor) and triglycerides. Recent studies also showed that TFA promote thrombogenesis and causes endothelial dysfunction. LA is known to decrease LDL cholesterol and lower postprandial lipemia. However recent studies have shown that at high intake of LA (>10 % of total energy) have a deleterious effect on cardiovascular risk factors particularly the inflammatory process and also decreases HDL cholesterol (8). Therefore LA intake should be moderated. Several lines of evidences have documented that LC n-3 PUFA (EPA and DHA) provided from fish/fish oils reduce CHD risk (9). The protective effects of LC n-3PUFA are mediated through multiple mechanisms, a) replacement of AA in membrane phospholipids shifts eicosanoids balance towards the '3'series which in turn produce anti-inflammatory, anti-aggregatory and vasodilatory effects b) decrease in plasma triglycerides and postprandial lipemia, c) improvement of endothelial dysfunction, and d) prevention of ventricular arrhythmias. Evidences relating dietary fats to the risk of developing a number of chronic diseases are summarized in Table – I.

Dietary fat Recommendations:

- Total fat intake (visible & invisible fat) should be 20-30 % of total energy for adults. The diet should provide more of PUFA and MUFA.
- Consumption of SFA should be < 10 % of total energy. For those having LDL cholesterol of ≥ 100mg/dl, the intake should be < 7 % of total energy. Intake of red meat, butter, cream and high fat dairy products should be restricted.
- MUFA intake should be between 10 – 15% of total energy.
- TFA have deleterious health effects and do not have any nutritional value. Hence intake of TFA should be kept as low as possible (< 1% of total energy). Limit intake of commercial bakery products like cakes, biscuits, sweets, deep fried foods and ready to eat foods.
- PUFA intake should be < 10 % of total energy. A minimum of 3% of total energy of LA is necessary to prevent the essential fatty acid deficiency. ALA intake should be 1-2 % of total energy. In addition to vegetable oils, intake of ALA rich foods such as green leafy vegetables, nuts, and seeds are necessary to meet the current recommendations. The optimal LA/ALA ratio should be 5-10.
- For cardiovascular health, LC n-3 PUFA (EPA+DHA) intake should be ~ 500mg/d. Intake of two servings (~ 200g) of fish per week (preferably oily fish) will provide sufficient EPA and DHA. For the treatment of existing cardiovascular diseases, 1g/d is recommended (under medical supervision) which can be achieved through intake of foods enriched with EPA and DHA or fish oil supplements.
- Dietary cholesterol intake should be < 300 mg/d. However for those with LDL cholesterol of ≥ 100 mg/dl, cholesterol intake should be < 200 mg/d. Avoid egg yolk, red meat and high fat dairy products which are the richest sources.

Optimal quality of fat intake for the prevention of diet related chronic diseases in Indians:

In India the major nutritional problems are chronic energy deficiency due to low fat intake and micronutrient deficiency. Due to this there is low birth weight of babies (because of poor maternal nutrition and antenatal care) resulting in intrauterine growth retardation. Apart from this, there is a transition where the country is experiencing economic development resulting in an increase in the number of the affluent and middle income groups due to rapid urbanization. As a result of this, there is a steep escalation in prevalence of obesity, diabetes and CHD. Fat intake in Indians is income dependent and highly skewed. Moreover there are regional preferences for the type of edible oil.

Sources of dietary fat are of two types namely invisible fat (fat present in the integral part of food items) and visible fat (added fat or fat contributed by vegetable oils, butter, ghee & vanaspati). Indian diets are mainly cereal pulse based and their intake in bulk significantly contributes to total fat intake. Taking into consideration the contribution of fats from all foods (invisible fat), the daily visible fat requirement for Indians (depending upon the physical activity & physiological status) range between 20 & 50 g/person (5,10). The current daily intake of visible fat in rural and urban poor is ~ 12g/person. Whereas urban high income group consume > 50g/person. Since chronic energy deficiency is the major nutritional problem in poor income group, increasing fat/oil intake can help to meet their energy needs. Because of increase in prevalence of obesity and diet related chronic diseases in urban population, the fat intake should be reduced. Diets of both rural and urban population provide LA levels ranging between adequate to high due to its high level in cereals and vegetable oils but ALA levels are low. Use of single oil containing high levels of LA such as sunflower oil & safflower oil will provide >10en% (recommended <10 en%). Therefore there is a need to moderate LA intake from visible fats. Assessment of PUFA nutritional status in adults belonging to different socioeconomic groups consuming different qualities and quantities of fat showed that n-6 PUFA nutritional status is good, but n-3 PUFA status needs to improve. Hence there is a need to moderate LA intake and increase ALA intake in Indian diets. Since consumption of single vegetable oil does not ensure optimal intake of fatty acids and their balance (particularly LA and ALA and their balance) use of a correct combination of 2 or more vegetable oils has been advocated (5). The recommended oil combinations (1:1) which provide optimal balance of LA and ALA are given in Table – II. Use of wide sources of vegetable oils also provides wider variety of minor components (tocopherols, oryzanol, phytosterols, lignans etc) some of them have hypocholesterolemic effects. Some of the oil combinations which lower LA but do not provide ALA. To ensure adequate ALA and optimal LA/ALA balance from the dietary components other than vegetable oils, an increase in the intake of ALA rich foods has been recommended (Table – III). Further, use of green leafy vegetables every day will increase ALA and also provide several micronutrients and fibers. Increasing n-3 PUFA nutritional status in Indians may contribute to several health benefits including the prevention of chronic diseases.

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Tables

TABLE 1 STRENGTH OF EVIDENCE ON DIETARY FAT AND RISK OF CHRONIC DISEASES

Evidence	Decreased risk	No relation ship	Increased risk
CHD			
Convincing	LC n-3 PUFA		SFA (C12:0 - C16:0) and TFA
Probable	ALA, Oleic acid	Stearic acid (C18:1)	
Type 2 Diabetes			
Possible	LC n-3 PUFA		SFA
Cancer			
Possible	LC n-3 PUFA		Animal fat

TABLE II: RECOMMENDED OIL COMBINATIONS IN INDIAN DIETS (OILS IN 1:1 PROPORTION)

Oil containing LA + oil containing both LA and ALA	Oil containing high LA + oil containing moderate or low LA
Groundnut/sesame/rice bran/cottonseed + mustard Groundnut/sesame/rice bran/cottonseed + canola Groundnut/sesame/rice bran/cottonseed + soybean Palmolein + soyabean Safflower/sunflower/palmolein + mustard	Sunflower/safflower + palmolein/olive Safflower/sunflower+ groundnut/sesame/rice bran

TABLE III. QUANTITIES OF FOOD REQUIRED FOR FURNISHING 0.1G OF ALA

Foods	Grams
Cereal/millet	
Wheat and pearl millet (bajara)	70
Pulses	
Black gram (kala chana), kidney beans (rajmah), and cowpea(lobia)	20
Vegetables	
Green leafy	60
Purslane(lunia)	25
Other vegetables	400
Fruits	
Raspberry	80
Avocado	90
Guava	100
Strawberry	155
Kiwi	240
Spices	
Fenugreek seeds (Mehti)	5
Mustard (sarson)	1
Nuts	
Walnut	1.1
Unconventional oil seeds	
Flaxseed (alsi)	0.5
Perilla seeds (Bhanjira)	0.3