

Benefits of Fats in Diet on Health of Patients Suffering from TYPE 2 Diabetes (NIDDM)

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ABSTRACT Fats, particularly saturated fats, are always considered to be health hazard due to its link with cholesterol level in blood, as evidenced by Framingham study. Raheja observed that in mid seventies of the past century Indians developed a strong belief that cholesterol in blood was the main offender leading to heart diseases latter on and changed the dietary patterns, particularly oil medium to poly unsaturated fatty acids rich oils like sunflower oil or safflower oil etc. taking these as cholesterol reducers. Different workers reported that optimum quantities of different groups of fats are essential for maintenance of health. It was found that the quality of fats and the life style patterns were most important in causing the diseases particularly type 2 diabetes mellitus and other related diseases like hypertension, coronary heart disease, dyslipidaemia, obesity. The paper shows the importance of lifestyle patterns in rural Bengalese in causing the disease and observed that their dietary fat intake was not detrimental to health of diabetics.

INTRODUCTION

Consumption of fat by average Indian is provided by diet particularly the oil used in cooking. In the Indian sub-continent proportion of fat consumed is related to income as reported by Ghafoorunissa (1996). The South Asian population is known to be at risk of atherosclerosis even though the subject does not have the clinical evidence of CAD (Krishnaswamy, 1989). Lands (1986) by observing the works done by various workers like Bang et al. (1971), Feldman et al. (1972) and Kromann and Green (1980) etc. on dietary pattern of Eskimos and the diseases they suffer concluded that the quality of fat was more important than its quantity. Of saturated fats palmitic acid and myristic acid are mostly cholesterolegenic, lauric acid is medium cholesterolegenic, but stearic acid is believed to be not so says Chow (1992), though some workers differ in this view (<http://www.mpopc.org.my/abtenbopo2.htm>). Neither palmitic acid nor myristic acid is cholesterolegenic in a patient with normal cholesterol level mentions Ng et al. (1992). Mediterranean diet may lower heart disease (Ornish, 1996). People in Mediterranean countries

eat as much as 40% of their calories as fats (mostly olive oil) but incidence of heart disease is low even for patients with low high density lipoprotein (HDL) and high triglycerides levels as the case of an average Indian (Enase, 1992). Diet with as little as 10% calories from fat and lifestyle program can reverse atherosclerosis. A diet too low in fat may actually lower the good HDL cholesterol and cause worse damage to arteries (Ornish, 1996).

The accumulation of excess energy in the body as fats is detrimental as it imparts more stress on hypothalamus to maintain homeostasis and as aging progresses the hypothalamus fails like a failing rheostat says Dilman (1989). Greenland Eskimos or natives of Micronesia who consume more fats do not get diabetes or dyslipidemic problems as they spent more energy due to their life style patterns (Ornish, 1996).

When total fatty acids are low, there is possibility of stimulation of peroxisomal oxidation of fatty acids. A number of structurally diverse chemicals have been found to cause higher levels of peroxisomes and proliferation in liver and other tissues (Reddy et al., 1983). Paradoxically, high fat diets cause such proliferation also (Reddy et al., 1992).

Role of fats

Relationship of Fats and Health:
Cholesterol is essential for maintenance of normal

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life process and for atheroma formation and so it should not be blamed as the only factor (Braunwald, 2005) for (?). It is now known that not only the amount, but also the type of dietary fat plays a major role in maintaining health (Simopoulos, 2004; Gohlke, 2004). The clinical importance of fatty acids is a consequence of their role in metabolic problems resulting from either their deficiency or over-abundance. In the brain, essential fatty acids (EFA) help to prevent stroke, possibly through potential mechanisms of decreased blood pressure, reduced platelet aggregation and enhanced deformability of erythrocyte cells. Conditions of the brain such as depression, attention deficit, hyperactivity disorder and pre-menstrual syndrome are also thought to be attenuated by EFA (Iso et al., 2002; Stevens et al., 2003; Puolakka et al., 1985). Pre-term infants deprived of vital fatty acids, particularly w-3 fatty acid, during late pregnancy are likely to have failures of normal development, especially development of the visual system (Auestad et al., 2003; Uauy et al., 2001) and are prone to diabetes in later life (Innis, 1992).

Higher palmitic and lower w-3 fatty acids in serum are correlated with higher incidence of coronary heart disease in middle-aged men at high risk for cardiovascular disease (Stamler, 1992). Renaud et al. (1995) reported that improvements in plasma fatty acids level by altering dietary intake and more of vitamins E and C in the diet leads to improvements in life expectancy and 70% lowering of heart disease.

Eicosapentaenoic acid (EPA) (20:5 w-3) insufficiencies are likely the most prevalent fatty acid abnormality affecting the health of persons in Western societies (Sreijic, <http://www.hsrmagazine.com/articles/511feat1.html>). Arthritis and heart disease, as well as aging, result from direct or indirect effects of unchecked inflammatory response. Supplementation with EPA-rich fish oils aids in the prevention of cardiac arrhythmias (Nair et al., 1997). Low EPA and Docosahexaenoic acid (DHA) in the presence of normal Alpha Linolenic Acid (ALA) indicate an inadequate conversion of ALA to EPA and DHA leading to increase in total cholesterol and triglyceride level in blood which can be ameliorated by a combination of garlic concentrate (900 mg/d) and fish oil supplementation (Adler et al., 1997). Although EPA can be produced from the essential fatty acid, ALA, dietary intake of this fatty acid is

generally poor as majority of Indians are lacto-vegetarians. The conversion also requires the action of the Δ -6 desaturase enzyme that may be at a low level by virtue of inadequate Zn, Mg, or vitamins B₃, B₆, and C. This is particularly important in some area of Bengal, as soil testing reveals Zinc is deficient in the soil due to successive cropping. Docosapentaenoic acid (DPA) (22:5 w-3) and Docosahexaenoic acid (DHA) (22:6 w-3) lead to attention deficit hyperactivity disorder (Stevens et al., 1995) and failures in development of the brain cells particularly visual system. Since this fatty acid is so important in early development, it is worth noting that the levels in breast milk are correlated with the mother's intake of fish oils or its substitute like flax oil (Handerson et al., 1992), which is a rich source of DHA and DPA. Failure of normal brain development leads to more incidence of diabetes (Kahn and Weir, 1996). Low levels of Linoleic acid (LA) (18:2 w-6) indicate dietary insufficiency, particularly reduced usage of cooking oils and fewer intakes of vegetables. Some of these symptoms result from lack of linoleic acid in membranes where it serves a role in structural integrity (Houwelingen et al., 1992). Linoleic acid levels are usually found above normal in most adults leading to an overproduction of the proinflammatory 2-series local hormones. LA is converted in the body to Gamma linolenic acid (GLA) (18:3 w-6) by the action of desaturase enzymes on linoleic acid. 1.4 g/day of linoleic acid in the form of borage seed oil has resulted in clinically important reduction in the signs and symptoms of rheumatoid arthritis (Leventhal et al., 1993). w-6 fatty acids enhance tumor formation and growth, while w-3 fatty acids inhibit tumors (Noguchi et al., 1995). Gamma linolenic acid corrects most of the biological effects of zinc deficiency (Huang et al., 1982) indicating that the requirement of the Δ -5 desaturase enzyme for zinc is a first-order essential function of zinc. Desaturase enzyme activities are reduced in diabetes (Chow, 1992). Conjugated linoleic acid (CLA), an omega-6 found in beef, lamb, dairy products and safflower oil, is found to have beneficial effects on immune function (Bassaganya-Riera et al., 2003; Maggiora et al., 2004; Hirao et al., 2004). CLA is most popularly touted as a safe means of body fat reduction and thus effective in diabetes (Wigham et al., 2004). Arachidonic acid (AA) is a

20-carbon of eicosanoate fatty acid that serves as substrate for the cyclooxygenase and lipoxygenase enzymes, leading to the production of the 2-series prostanoids and leukotrienes. Several of these products have potent proinflammatory and thrombogenic activity. Low levels of Docosatetraenoic acid (DTA) (22:4 w-6) in blood indicate essential fatty acid deficiencies in weight reducing programmes involving low intake of dietary fats. Vaccenic acid (14:1 w-9) and Palmitoleic acid (16:1 w-9) ratio has been reported to be a valuable indicator of biotin deficiency (Shigematsu et al., 1997). Biotin acts as a co-factor in various reactions in the body particularly in premature graying of hair in diabetic (Chaudhuri, 1988). Vaccenic acid also seems to have large effects on membrane fluidity. Inhibition of tumor growth in cell culture has been reported for vaccenic acid by Awab et al. (1995). Oleic acid is the principal lipid of a class that makes LDLs resistant to oxidation and thus a diet rich in oleic acid reduces foam cell accumulation rates and thereby lowers the chances of atherosclerosis (Anonymous, 1990). It exerts beneficial effects on glycaemia, blood pressure and lipid metabolism by lowering levels of low-density lipoprotein (LDL) and increased levels of high-density lipoprotein (HDL) cholesterol. It reduces the waist-hip ratio, the principal determining point in reducing insulin resistance (Sreijic, <http://www.hsrmagazine.com/articles/511feat1.html>). A profound shift in the ratio of stearic to oleic acids leads to tumor formation (Apostolov et al., 1985).

Erucic acid (22:1 w-12) is present in mustard oil. This fatty acid may be responsible for the response of selective persons to preparations containing rape and mustard seed oils with adrenal leukodystrophy (Rizzo et al., 1989). A pattern of low levels of the shorter chain fatty acids and high levels of longer chain fatty acids may indicate a fatty acid restricted diet in which case there is a stimulation of hepatic synthesis and elongation enzymes. There are a large number of known genetic disorders involving accumulation of sphingolipids, usually due to the lack of enzymes needed to maintain the turnover of membrane components. The level of behenic, lignoceric, and hexacosanoic acids as well as that of the unsaturated members of the C22-24 classes, especially nervonic, are found elevated in such cases. Accumulation of Behenic acid (22:0), Lignoceric acid (24:0) and

Hexacosanoic acid (26:0) are associated with degenerative diseases of the central nervous system, such as adrenal leukodystrophy.

Odd-chain fatty acids build up in membrane lipids of nervous tissue result in altered myelin integrity and demyelination, leading eventually to impaired nervous system functioning (Frenkel et al., 1973). This happens due to significant gut dysbiosis common in rural Bengal due to chronic infections and intake of meat of ruminant animals and dairy products (Mitra and Bhattacharya, 2005).

Palmitelaidic acid (16:1 w-9t) and Elaidic acid (18:1 w-9t) are fatty acids that contain one double bond and thus are included in the unsaturated category. Because of the geometry of the trans bond, however, they behave like saturated fats on the one hand, leading to higher cholesterol levels (Abbey et al., 1994); and on the other, they mimic unsaturated fats in binding to desaturase enzymes and interfering with the normal production of critical products. The net effect is to raise plasma LDL and lower HDL.

Role of Diet in Consumption of Fatty Acids:

Because of the life-supporting functions of forming cell membranes, acting as energy sources and for synthesis of several hormones to maintain homeostasis the supply of fatty acids through the diet must be continuous, even during short intervals between meals or in the fasting state when fatty acids are either produced from carbohydrates or proteins or are mobilized from adipose stores.

A person on a low-fat, high-carbohydrate diet utilizes the fatty acid synthetic pathway extensively; this pathway requires citrate to leave the mitochondria to generate malonyl-CoA. The resultant high concentration of malonyl-CoA inhibits the activity of the enzyme, which leads to fatty acid oxidation. It is for this reason that extreme low-fat diets do not result in weight loss nearly as fast as one might expect (Chaudhuri, 1988). Dramatically increased fatty acid oxidation occurs in starvation and diabetes mellitus with production of ketone bodies in excess that accumulate to give the ketoacidotic condition.

Fatty acids can be synthesized from acetyl-CoA derived from carbohydrate, protein, and other non-lipid sources. This pathway produces saturated fatty acids, predominantly palmitic acid (16:0). Palmitic acid can be desaturated, forming the w-7 class of unsaturated fatty acids or can be

lengthened to stearic acid (18:0) and further to form oleic of the w-9 class. Under ordinary metabolic conditions these two classes are not further lengthened or desaturated to any appreciable extent.

The w-6 and w-3 classes of unsaturated fatty acids are essential fatty acids and derived from dietary polyunsaturated fats. These classes can be further lengthened and desaturated. None of the four w- classes of unsaturated fatty acids, however, are inter-convertible. These reactions can be repeated in various combinations, giving an array of saturated and unsaturated fatty acids for use in the essential functions of tissue maintenance (Chow, 1992).

The desaturase enzymes function to place double bonds at positions up to 9 carbons from the carboxyl end of the molecules. When counted from the other end, the position varies, depending on the length of the fatty acid. These differences become important because the type of eicosanoid hormones that can be formed later depend on the position of the first double bond from the methyl end. The activity of the desaturase enzymes is critical for maintaining the ratio of saturated and unsaturated components in cell membranes. Tumor tissue and virus-transformed cells have a higher content of unsaturated fatty acids, especially oleic acid, which increases relative to the amount of stearic acid (Wood et al., 1985; 1995).

A group of researchers in a study done in 2005 from Harvard School of Public Health (<http://www.hsph.harvard.edu/nutritionsource/fats.html>, 2005) examined the long term relationship between different types of dietary fat and the risk of Type 2 diabetes. More than 84, 000 women aged 34 through 59 were involved in the study. All were free of diabetes, cancer, and cardiovascular disease at the start of the study. After 14 years, slightly more than 2,500 cases of Type 2 diabetes were documented. Based on dietary information gathered periodically over the course of the study, the researchers concluded that trans fatty acids increased the risk of Type 2 diabetes in women. Trans fatty acid levels in cell membranes are determined by dietary intake of hydrogenated oils (Pettersen et al., 1992). Polyunsaturated fatty acids particularly w-3 fats (found in fish, flaxseed, pumpkin seed, canola, soy, and walnuts) appear to reduce the risk.

The Δ -6 desaturase shows substrate binding

affinity increasing greatly with the number of double bonds present. Thus 18:3 binds stronger than 18:2, which binds stronger than 18:1. When the two essential fatty acids are absent, however, 20:3 w-9 accumulates because the desaturase is free to act on oleic acid. Elevated 20:3 w-9 (eicosatrienoic acid) is a marker of essential fatty acid deficiency that could be used in addition to the actual concentrations of the essential fatty acids in plasma and erythrocyte membranes (Chow, 1992).

The primary function of the pathway described above is to supply the parent compounds for the 1-, 2-, and 3-series prostanoid and leukotriene pathways. The PUFAs have great impact on health on account of their conversion to these compounds, collectively called eicosanoids. They possess extremely potent biological activities and their homeostatic functions in regulating blood vessel leaking, lipid accumulation and immune cell behavior are relevant to the initiation and progress of heart and blood vessel disease (Stamler, 1992).

Since dietary intake is a primary determinant in the balance of the fatty acids that go into this pathway, here a direct link exists between the balance of specific fats in the diet and long-term health (Horrobin, 1982; Seymour et al. 1993). The fatty acid profile allows specific intervention where the imbalance is most prevalent so that inflammatory responses and other local control processes remain in control.

MATERIALS AND METHODS

80 NIDDM patients were selected randomly from the surrounding of Kharagpur and are divided in 2 homogenous groups of 40 patients each. The patients underwent clinical and anthropometrical evaluation before the study. Initial blood samples were analysed for plasma glucose, insulin and lipid profile. The patients were not taking any lipid lowering, anti-hypertensive and anti-diabetic drugs. Both the groups were instructed to maintain identical schedules as far as practicable with only variation being differences in dietary intakes. 1st group was instructed to take food containing about 30% of fats as per guidelines given by American Diabetic Association (ADA) for 1 year and the 2nd group usual diet as they consume day-to-day which on being analysed (based on methods described in Rangana, 1986) was found to be 70-80% of

carbohydrates, 10-20% of protein and about 10% of fats. Diet was formulated accordingly by providing information of different ingredients of the food items and on acceptability. Variability of dietary constituents was also considered while formulating and monitoring. Since the patients at and around Kharagpur were engaged in some or other kind of physical activities, it was designed that both groups of patients should perform similar type of physical activities so that the burning out of the calorie intake would remain by and large similar for all the patients. Besides the patients were advised to undergo regularly some physical exercise in the form of commercially available 'walkfit programme' (Snowdon et al, 1993). Blood samples from the patients were taken by an indwelling catheter in the ante-cubital vein and analyzed for fasting blood glucose (FBS), triglycerides (TG), total cholesterol (TC), high-density-lipoprotein cholesterol (HDL), low-density-lipoprotein cholesterol (LDL), very low-density-lipoprotein cholesterol (VLDL). The tests were conducted as per Instruction sheets for manual assays given by Boehringer Mannheim Limited (1983) and the instrument used was photometer 4010 (Boehringer, Germany). Blood samples were taken at 3 monthly intervals in the patients receiving 30% of fats and at monthly interval in the 2nd group receiving usual rural diet. The monthly reading is taken to compare and also to see seasonal variations.

RESULTS AND DISCUSSION

The results of clinical and anthropometrical evaluation before the study were:

1st group

Sex: Males 23, Females 07

Age: 48.29 ± 4.56 years (± indicates range)

Weight: 79.26 ± 13.02 kg

Body Mass Index (BMI): 24.46 ± 3.29

2nd group

Sex: Males- 23, Females- 07

Age: 47.79 ± 3.64 years

Weight: 77.29 ± 6.02 kg

Body Mass Index (BMI) : 23.42 ± 2.49

At the end of study the clinical and anthropometrical evaluations were again done in both the groups. The variations are statistically insignificant.

The lipid profile of the patients with 30% fat

diet (as per guidelines of American Diabetic Association) has been shown in Table 1. It appears that the parameters of lipid profile such as TC and LDL, along with FBS was slightly increased.

Table 1: Effect of Fat on lipid profile of NIDDM patients (rural), diet with 30% fat

Time (months)	TC (mg/dl)	HDL (mg/dl)	LDL (mg/dl)	VLDL (mg/dl)	TG (mg/dl)	FBS (mg/dl)
1	252±12	56±9	178±7	18±3	94±7	162±9
4	255±9	55±6	180±10	19±5	95±9	165±8
8	258±11	57±5	182±8	19±2	95±4	168±6
12	255±11	57±9	179±10	19±7	95±7	165±8

It can be observed that the lipid biochemistry of the patients fed with more fat (30%) did not change significantly. It can be concluded in general that even if the patients suffering from diabetes are fed with fat to the extent of 30% of the total calorie(?) in the diet maintaining ADA guidelines, as saturated fat: mono unsaturated fat: poly unsaturated fat :: 7 : 12 : 11, the chance of proliferation of the disease is less. Table 2 presents the effects of average rural diet (80-90% carbohydrate) on desired blood parameters. Result showed both blood sugar and blood cholesterol, particularly LDL cholesterol, increased in winter. FBS increased in rainy season also. Both reduced in summer and autumn. Comparing the results showed that the two different dietary regimens show no significant variations in different blood parameters like TC (p=0.025), HDL (p=0.05), LDL (p=0.50), VLDL (p=0.50), TG (p=0.50) and FBS (p= 0.50) respectively.

Analysis of fasting serum insulin values in the group receiving more fats was 109±26 units (initially) and it was 102±21 units at the end of study and in the group receiving rural diet fasting serum insulin values was 102±18 units (initially) and it was 112±26 units at the end of study needing further studies. Mitra and Bhattacharya (2005) found that rural diet is more diabetogenic.

South Asians, particularly Indians, who are highly prone to CAD due some yet unexplained reasons, are also insulin resistant, which may be due to maternal malnutrition and low birth weight (Vardhans et al., 1995; Bhatia, 1995). Enase et al. (1992) had called for a thrifty gene necessitating a high CAD risk and a nature-nurture phenomenon. As a result of insulin resistance b cells of pancreas secrete more and hyperinsulinaemia is a defense

Table 2: Effect on lipid profile of NIDDM patients (rural) fed with less fat and more carbohydrate in the diet (Normal rural Indian diet)

	Time	TC	HDL	LDL	VLDL	TG	FBS
Dec	0	252	56	178	18	94	162
Jan	1	254	56	180	18	94	164
Feb	2	258	56	184	18	94	167
Mar	3	255	58	179	18	94	163
Apr	4	254	57	179	18	94	164
May	5	254	57	178	19	98	163
June	6	252	56	176	20	102	165
July	7	252	56	176	20	102	165
Aug	8	250	56	174	20	102	163
Sep	9	250	56	176	18	94	163
Oct	10	250	56	176	18	94	162
Nov	11	253	56	179	18	94	162

against glucose intolerance and diabetes. Keeping in mind the role of insulin the condition has profound repercussions on metabolism, protein synthesis, growth and angiogenesis. The cause of insulin resistance may be environmental and more food intake and reduced physical activities are implicated. Although hyperinsulinaemia is adaptive, it becomes maladaptive if the individual has inherited a gene (the diabetes gene), which limits the pancreas to augment the secretion and increase of insulin resistance (IR) leads to frank diabetes.

The present study showed that average Indian diet when coupled with exercise programs did not cause any adverse changes due to controlled fat intake in a diabetic and the clinician without any adversity can make minor changes in the diet provided life-style includes physical activities and exercises.

CONCLUSION

Because of the critical life-supporting functions in forming cell membranes and supplying energy sources and hormone controls fats are essential. Essential fatty acids are converted in the body to eicosanoids and are to be supplied in the diet. Different fats have different functions such as prevention of neurological diseases, adequate behaviour development, prevention of tumors and various other disorders. Rural Bengal diet is rich in simple carbohydrates (about 80%) and it does not cause clinical deterioration in a rural diabetic in a short-term study though there is marginal seasonal impact. The study also showed that controlled fats in the diet coupled with regular

exercise is not detrimental to health even of a diabetic.

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