FATTY ACIDS AND HUMAN HEALTH

T.A.B. SANDERS

Summary

The role of high intakes of fat in the causation of disease has preoccupied bodies concerned with formulating dietary guidelines. Yet scant attention has been paid to the requirements for fat in the diet. The physiological effects exerted by fat depend upon its fatty acid constituents which vary chain-length, degree and geometry of unsaturation. The effects exerted also depend upon the dose and relative proportions of other fatty acids in the diet. Manipulation of the relative proportions of fatty acids in the diet may be of value in the prevention and treatment of several disorders. It is suggested that there may be a need to develop the concept of fat quality. It is no longer justifiable to generalise about fat as a homogenous group of substances.

I. INTRODUCTION

Human diets vary not only in the amount of fat consumed but in the type of fatty acids provided. As a general rule as countries become more affluent they consume more fat. Although a high proportion of the total fat intake is derived from dairy and meat fats in western countries, avoiding these foods does not ensure a low fat intake. For example, vegans who consume none of these foods derive about 35% of their energy from fat. Until recently dairy fat was a major source of saturated fatty acids in most developing countries. The advent of spreads low in saturates and increased popularity of skimmed milk has meant that the contribution of dairy fats to total fat intake has decreased. Surprisingly total fat intake has not changed appreciably probably because the increased consumption of processed foods and meat products. On the other hand the intake of linoleic acid has increased markedly as a result of the increased consumption of vegetable oils and soft margarine (Hetzel et al. 1989). Trans fatty acid intakes have probably remained static and they consist in the main of trans monounsaturates. As the intake of linoleic acid has risen so has the ratio of n-6 to n-3 fatty acids in the diet. There has been a decline in the intake of n-3 fatty acids provided by fish, offal, eggs and dairy products and a decline in the intake of monounsaturated fatty acids (mainly oleic acid). The implications of these changes with regard to health will be discussed.

Department of Nutrition & Dietetics, King's College, London W8 7AH.

II. THE NEED FOR FAT IN THE DIET

Fat plays an important role in meeting energy requirements, increasing the palatability of the diet and facilitating the absorption of fat soluble vitamins. Although the role of fat in providing energy is a dispensable one it is important in providing sufficient energy density in the diets of the very young. The fact that most of the energy is human milk is provided by fat and that xeropthalmia is common in toddlers in parts of the world where fat intakes are low argue that high fat intakes are desirable in the under-fives.

The indispensable role of fat is the provision of essential fatty acids (EFA) - linoleic (18:2n-6) and α-linolenic (18:3n-3) acids and their respective derivatives. The EFA are important structural constituents of cell membranes and also give rise to eicosanoids (prostaglandins, thromboxanes, prostacyclins and leukotrienes) which are involved in regulation of cellular metabolism. As a general rule eicosanoids derived from the n-6 family are biologically active whereas those derived from n-3 series are inactive or only weakly active.

The n-6 family is required for the maintenance of the transepidermal water barrier, normal skin differentiation, prostaglandin and leukotriene formation and growth. The n-3 family have different but specific functions particularly in the photoreceptor membranes of the retina and in nerve synapses. The n-3 fatty acids also have effects on modulating the production of active eicosanoids. Both families need to be balanced with respect to one another. The estimated requirements for n-6 and n-3 fatty acids are approximately 1% and 0.5% of the energy intake respectively. In addition there is some evidence that the long chain derivatives of both series may need to be provided in the diets of premature infants (Sanders 1988).

III. OPTIMUM INTAKE

Obesity

There is little doubt that diets high in fat are conducive to obesity in adults because of their high energy density. However, there is little evidence that variations in the proportion of energy derived from fat contribute to causing obesity.

Cardiovascular disease

High intakes of saturated fat have been linked to coronary heart disease (CHD) by at least two separate mechanisms: saturated fatty acids increase total and low density lipoprotein (LDL) concentrations; a high intake of saturated fat increases the tendency of the blood to clot. There is a general consensus among expert committees that saturated fat should not provide more than 10% of the energy intake (European Atherosclerosis Society 1987). In communities with a high incidence of CHD , the intake of saturated fat typically ranges between 15 and 25 % of the energy intake. Much of which is provided by fatty meats and milk fat.

There is also general agreement that the intake of fat from these sources should be reduced. What , however, is unresolved is which nutrients should replace the energy provided by saturated fat. In order to achieve the recommendation, it is necessary to replace about 10% of the energy intake.

Both high carbohydrate and modified fat diets lower LDL cholesterol compared to a high saturated fat diet (Grundy,1989). But compared with modified fat diets, high carbohydrate diets have a number of disadvantages: they are less palatable, they lower the concentration of high density lipoprotein (HDL) cholesterol (a protective factor against CHD) and may impair glycaemic control in certain individuals. A high carbohydrate diet (25% energy from fat) is no more effective lowering LDL cholesterol than a modified fat diet. Modified fat diets are ,therefore, to be preferred for cholesterol lowering. Consequently there appears to be no benefit in terms of cholesterol lowering from decreasing total fat intake from below 30-35% energy (Demke & Breslow 1988; Ginsberg et al.1990). On the other hand a reduction in total fat intake is associated with a reduction in clotting factor VII activity (Miller et al.1989).

Polyunsaturated oils such as sunflower and corn oils have traditionally been advocated for the replacement of saturated fat. For each 1% energy of saturated fat replaced by linoleic acid there is a 0.13 mmol/l reduction in plasma cholesterol. Intakes of linoleic acid up to 12% of the energy do not lower HDL (Mensink & Katan 1989) but higher intakes do.

The replacement of saturated fat with linoleic or oleic acid has an equivalent LDL cholesterol lowering effect. However, the trans isomer of oleic acid has a slight cholesterol raising effect intermediate between oleic and palmitic acid (Mensink & Katan,1990). Stearic acid (18:0) does not have a plasma cholesterol raising effect in man (Bonanome & Grundy 1988). This may be because it is rapidly converted to oleic acid in the body. It now seems that only certain saturated fatty acids (C12-C16) increase LDL cholesterol. As both stearic acid and medium chain triglycerides are highly thrombogenic in animal models caution should be exercised before advocating increased intakes.

The n-3 polyunsaturated fatty acids derived from fish oil have different effects on plasma lipids from linoleic acid and the effects observed are strongly dose related (Harris 1989; Sanders 1989). Both eicosapentaenoic acid (EPA;20:5n-3) and docosahexaenoic acid (DHA; 22:6n-3) can markedly lower plasma triglycerides and VLDL concentrations. Linoleic acid and linolenic acid do not show the same effect at comparable doses. Moderate intakes of EPA and DHA increase HDL cholesterol but high intakes decrease HDL cholesterol similar to that seen with very high intakes of linoleic acid. Chylomicron clearance is also increased in subjects following the consumption of oily fish. Although large amounts of fish oil do lower LDL cholesterol, moderate intakes of fish oil concentrates are not regarded as useful for the treatment of hypercholesterolaemia (Wilt et al.1989).

Both inter and intra-population studies show a relationship between fish consumption and protection from coronary heart disease (Kromhout et al.1985). It is believed that the protection offered is independent of any effect on plasma cholesterol concentrations. Several studies have shown that fish oil lowers blood pressure in normal and hypertensive patients. This effect is not observed with comparable doses of linoleic or linolenic acid. Bonaa et al (1990) found a lower incidence of hypertension in subjects who consumed fish regularly and showed that EPA and DHA supplementation lowered blood pressure in individuals with low intakes of fish. Fish oil supplements have also been shown to prolong template bleeding time and decrease whole blood viscosity.

A beneficial effect on total mortality of consuming oily fish twice a week has been reported in patients who had previously suffered a myocardial infarction (Burr et al.1989). However, the amount of EPA provided by the oily fish was only 3 grams/ week which is considerably less than the amounts used in most experimental studies that have demonstrated changes in haemostatic function. While very small amounts of n-3 fatty acids might offer protection possibly by influencing susceptibility to cardiac arrythmia, fish might also supply an unidentified protective factor.

Cancer

A decrease in total fat intake has also been recommended by some authorities for the prevention of cancer. While it is possible to make associations between countries with regard to risk of cancer of the colon, breast and prostate and total dietary fat intake, the same relationship is generally not found in prospective studies inside countries. For example a prospective study of 89,500 nurses concluded that there was no relationship between fat intake and breast cancer (Willet et al 1984). However, the lowest quintile of fat intake in this study was 32% of the energy, well above the level of 20-25% energy seen in low risk countries such as Japan (Schatzkin et al.1989).

Animal studies show that high fat diets promote the growth of many tumours but this effect can be abrogated by energy restriction. Linoleic acid promotes tumour growth in experimental animals in a dose dependent manner up to 4% of the energy intake. It has been argued that this may reflect a requirement of the tumour for EFA (Ip 1987). However, high intakes of EPA and DHA inhibit tumour growth in several animal models.

IV. ROLE OF N-3 AND N-6 FATTY ACIDS AS PHARMACOLOGICAL AGENTS

High intakes of fish oil containing EPA and DHA display several pharmacological properties: inhibition of inflammation, antithrombotic effects, altered lipoprotein metabolism, inhibition of atherosclerosis, inhibition of tumour growth (Leaf & Weber 1988). Fish oil preparations are effective in decreasing plasma triglycerides in patients with types IIb, III, IV, V hyperlipoproteinaemias. But they may cause a deterioration in glucose tolerance in non-insulin dependent diabetics (Glauber et al.1989) and lead to an increase in LDL in patients with Type IV and V (Sanders,1989) as with other triglyceride lowering drugs. Oils containing gamma-linolenic acid (18:3n-6) have been shown to relieve the itching in eczema, to give symptomatic relieve in premenstrual tension and to have a hypotensive effect (Horrobin 1990).

V. INTERACTION WITH ANTI-OXIDANT NUTRIENTS

Increasing the intake of polyunsaturated fatty acid increases the requirement for anti-oxidant nutrients especially vitamin E and selenium. Yellow fat disease can occur in a number of animal species fed unhydrogenated fish oils without sufficient vitamin E (Danse & Vershuren 1978). The amount of vitamin E required is approximately 0.4 mg/ gram of linoleic acid. Fortunately, dietary sources of linoleic acid are rich in vitamin E. In contrast, fish oils and animal fats tend to be low in the vitamin. Glavind et al(1976) suggest that as much 10mg vitamin E/g n-3 fatty acids may be needed to prevent lipofuscin accumulation. Further studies on the influence of n-3 fatty acids on anti-oxidant requirements are needed.

VI. CONCLUSION

Although small amounts of essential fatty acids in the diet are necessary, their importance in human diets is probably related to the effects exerted by higher intakes and by the relative balance between the n-6 and n-3 series. Enthusiasm for recommending increased intakes of polyunsaturated fatty acids should be tempered with the knowledge that there are interactions between polyunsaturated fatty acids and other nutrients. There is clearly a need to define upper as well as lower limits to the recommended intakes of essential fatty acids. In the USA intakes are in the order of 6-8% energy compared with 4% in the UK. Current opinion is that it may not be wise to increase intakes above 8% of the energy intake. Very high intakes of linoleic acid suppress the immune system and are associated with an increased risk of gall-stones and suppress the metabolism of the n-3 series of polyunsaturated fatty acids.

The FAO/WHO (1977) recommendation suggests a reduction in total fat to 30% with equal proportions from each fatty acid type with the polyunsaturated fatty acids being provided by linoleic acid. The advocated diet encouraged changes which are now regarded as undesirable namely a reduction in the intake of monounsaturates and an increase in the ratio of n-6 to n-3 fatty acids. It is clear that the simplistic message propagated that "fat is bad for you" needs qualification. In future more attention should be focused on the positive and negative effects of specific fatty acids. It is suggested that there is a need to develop a measure of the quality of fat in the diet.

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