What is the desirable ratio of saturated, polyunsaturated, and monounsaturated fatty acids in the diet?[1,2]

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ABSTRACT By reducing intakes of animal fats and gradually reducing intakes of *trans* fatty acids, a one-third reduction in cholesterol-raising fatty acids seems practical, from 12% to 7–8% of total energy intake. The intake of polyunsaturated fatty acids should not exceed current intakes, ≈7% of total energy. Although further research is needed to determine a recommended ratio of oleic acid to carbohydrates, on the basis of the relatively low rates of coronary artery disease and cancer in both the Mediterranean region (where oleic acid intake is high at the expense of carbohydrates) and in populations consuming low-fat, high-carbohydrate diets, a reasonable compromise is a diet in which total fat is ≈30% of energy, allowing for an intake of oleic acid of 15–16% of total energy. *Am J Clin Nutr* 1997;66(suppl):988S–90S.

KEY WORDS Animal fats, oleic acid, polyunsaturated fatty acids, monounsaturated fatty acids, saturated fatty acids, Mediterranean diet

SATURATED FATTY ACIDS

Abundant evidence indicates that some dietary saturated fatty acids raise serum cholesterol concentrations. These include palmitic acid (1–7), myristic acid (7), and lauric acid (6). In contrast, another saturated fatty acid, stearic acid, does not raise serum cholesterol (3, 8–13) and it is uncertain whether the medium-chain saturated fatty acids do or not. Thus, at present there are with certainty only three types of cholesterol-raising saturated fatty acids: lauric acid (12:0), myristic acid (14:0), and palmitic acid (16:0). These three fatty acids, however, make up about two-thirds of the saturated fatty acids in the American diet.

The question of just how much the cholesterol-raising saturated fatty acids raise cholesterol concentrations must be preceded by the question "relative to what?" It has become conventional to use monounsaturated fatty acids [such as oleic acid (18:1)] as the baseline or neutral fatty acids. By this is meant that oleic acid neither raises nor lowers total cholesterol concentrations. Oleic acid is a convenient baseline fatty acid and considering it to be a neutral fatty acid puts the effects of other fatty acids into perspective. Although there is not uniform agreement on the absolute or relative cholesterol-raising potential of the different cholesterol-raising saturated fatty acids, current estimates suggest that palmitic acid raises total cholesterol concentrations by ≈0.06 mmol/L (≈2.5 mg/dL) for every 1% of total energy used in replacement of oleic acid (14). Limited data indicate that lauric acid raises cholesterol concentrations by about two-thirds that of palmitic acid (6), whereas myristic acid raises concentrations by somewhat more than palmitic acid (1, 7).

The use of standard diet equations to estimate effects of saturated fatty acids must be tempered by the realization that there is considerable variation in response. The equations represent only average responses defined in relatively small groups of people. Whether men and women respond similarly has never been determined with certainty (15). Some people appear to be hyperresponders whereas others are hyporesponders to saturated fatty acids (16, 17). The amount of cholesterol in the diet may affect the response as well (18). Likewise, the absolute response may depend on a particular individual's baseline concentration of cholesterol (19, 20); those with higher cholesterol concentrations appear to respond best to the removal of saturated fatty acids from the diet. The reasons for these differences in responses are unknown, but current data suggest that cholesterol-raising saturated fatty acids exert their effect primarily by suppressing the expression of low-density-lipoprotein (LDL) receptors in the liver (21). Likely a variety of factors regulating hepatic cholesterol metabolism modify the influence of these fatty acids on LDL-receptor expression. It is presumed that oleic acid does not suppress LDL-receptor activity. Note that the major effect of cholesterol-raising saturated fatty acids is on LDL-cholesterol concentrations. There are little or no differences between effects of saturated fatty acids and effects of oleic acid on high-density lipoprotein (HDL) or very-low-density lipoprotein (VLDL) concentrations.

Some workers have used carbohydrate instead of oleic acid as the neutral nutrient. It is true that carbohydrates and oleic acid have similar effects on total cholesterol concentrations (2, 4, 8, 22–26). However, the use of carbohydrates as the reference point seems to be highly inappropriate from a conceptual point of view. Carbohydrates seem to affect lipoprotein metabolism entirely differently from fats. They enhance VLDL concentrations by enriching VLDL particles with triacylglycerol (2, 24, 26–29). They reduce the LDL-cholesterol concentration by reducing the cholesterol content of LDL particles, not by reducing the number of circulating LDL particles (30) as dietary oleic acid does (1). Furthermore, carbohydrates reduce HDL-cholesterol concentrations (2, 23, 30–34) whereas oleic

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Am J Clin Nutr 1997;66(suppl):988S–90S. Printed in USA.

acid does not (1, 2, 23). Considering the marked differences in mechanism of effect, it seems best to leave carbohydrates out of the dietary fat-cholesterol equation.

trans MONOUNSATURATED FATTY ACIDS

Recent investigation has shown that one type of monounsaturated fatty acid, the *trans* fatty acids (such as *t*-18:1), raise cholesterol concentrations relative to *cis* fatty acids (such as 18:1) (5, 35–39). *trans* Monounsaturated fatty acids apparently raise LDL-cholesterol concentrations about two-thirds as much as does palmitic acid, and they may have a small HDL-lowering action as well. For these reasons, it now seems appropriate to add *trans* fatty acids to the list of cholesterol-raising fatty acids and to subtract stearic acid. There are about equal amounts of these two types of fatty acid in the American diet, so when stearic acid is subtracted and *trans* fatty acids added, total amounts of cholesterol-raising fatty acids in the diet would equal the current intake of saturated fatty acids, ie, ≈12% of total energy.

POLYUNSATURATED FATTY ACIDS

A final category of fatty acids is the polyunsaturated fatty acids. In this category, linoleic acid (18:2) is the predominant fatty acid. A considerable body of evidence suggests that linoleic acid lowers total cholesterol concentrations relative to oleic acid (8, 9). This differential effect may extend to all of the lipoprotein fractions—VLDL, LDL, and HDL—although considerable individual variability in response exists. Recent analysis of available data indicates that linoleic acid lowers LDL-cholesterol concentrations slightly more than does oleic acid (14), but not as much as was previously reported (8, 9). For practical purposes and for effects on cholesterol concentrations, it seems to matter little which type of unsaturated fatty acid replaces cholesterol in the diet.

There are other concerns about increasing linoleic acid intakes above current amounts, however. No populations have ever consumed large amounts of linoleic acid with proven safety. This contrasts with high intakes of oleic acid in the Mediterranean region, where large amounts of olive oil are consumed; in this region, rates of coronary artery disease are low, as is total mortality (40). In laboratory animals, high intakes of linoleic acid can promote chemical carcinogenesis (41, 42) and suppress the immune system (43); the same is not true for oleic acid. Limited epidemiologic data further suggest that high linoleic acid consumption can increase the risk for human cancer. Finally, linoleic acid enriches membrane phospholipids and predisposes them to free radical oxidation. This could lead to harmful effects, such as accelerated aging or increased cancer risk. An example is the increased susceptibility of LDL to oxidation associated with high intakes of linoleic acid (44–48); this effect theoretically could predispose to enhanced atherogenesis.

CONCLUSION

In summary, the cholesterol-raising fatty acids should be reduced in the diet as much as is practical to effect a substantial lowering of serum cholesterol concentrations. Current intakes are ≈12% of total energy. By further reducing intakes of animal fats (ie, fat from meat and milk sources) and by gradually reducing intakes of *trans* fatty acids, a reduction of cholesterol-raising fatty acids by about one-third seems practical. This will reduce the contribution of these fatty acids to total energy intake to 7–8%. For the general population such a reduction seems reasonable and practical. Furthermore, because of the potential harmful effects of high intakes of polyunsaturated fatty acids, consumption probably should not exceed current intakes, ie, ≈7% of total energy. Thus, the ratio of cholesterol-raising fatty acids to polyunsaturated fatty acids probably should be about one-to-one, with total intakes of each being in the range of 7% of total energy.

The desirable intake of monounsaturated fatty acids is more difficult to define. Some investigators recommend higher intakes of monounsaturated fatty acids, whereas others suggest lower intakes in favor of more carbohydrates. The critical question therefore becomes what is the desirable ratio of oleic acid to carbohydrate. Current data do not allow for a definite answer to this question. Higher intakes of oleic acid at the expense of carbohydrate are well tolerated in the Mediterranean region where rates of both coronary artery disease and cancer are relatively low. The same, however, is true for populations consuming low-fat, high-carbohydrate diets. A reasonable compromise for the general public that considers both practicality and safety is to limit total fat to ≈30% of total energy. Such a diet will allow for an intake of oleic acid of 15–16%. A diet of this type is recommended currently by the American Heart Association for the general public. However, for individuals, depending on personal preferences, intakes of oleic acid can vary from 10% to 20% of total energy. This range will allow for a ratio of oleic acid to linoleic acid (or to cholesterol-raising fatty acids) to vary from 1:1 to 3:1. For most people this range appears to be healthy. For some patients, especially those with insulin resistance or non-insulin-dependent diabetes mellitus, a higher intake of monounsaturated fatty acids, at the expense of carbohydrate, can mitigate hypertriglyceridemia and hyperglycemia (24, 26). Further research nonetheless is needed to define the most desirable intake of oleic acid for the general population, as well as for specific subpopulations. This issue appears to be of growing importance because of an increasing divergence of opinion based on insufficient data.

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