The role of dietary fats in plant-based diets[1–3]

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ABSTRACT In the United States, the notion that low-fat, high-carbohydrate diets are essential for health has grown into an obsession, driven largely by an effort to reduce heart disease and, more recently, certain types of cancer. We know that saturated fatty acids are more closely associated with risk factors for heart disease than are unsaturated fatty acids. Many people believe that plant-based diets are healthy because they are low in fat. However, plant-based diets are not necessarily low-fat. In true plant-based diets, unsaturated fatty acids predominate, whereas saturated fatty acids come largely from animal sources such as dairy products and eggs. Plant-based diets include foods that contain fats, such as nuts and seeds and oils from grains and seeds. The fats in these foods are not associated with increased risk for heart disease. In addition, for people with insulin resistance, higher-fat diets protect against the heart disease risk factors of low HDL-cholesterol concentration, hypertriglyceridemia, hyperglycemia, and hyperinsulinemia. Because humans can synthesize fat from dietary carbohydrate, and because our adipose stores and circulating fatty acids reflect dietary intake, scientists understand the relations between the amounts and types of dietary fats and the types of fats found in body fat depots. Consuming dietary fats that are not associated with increased risk of disease can be a part of a healthful diet. *Am J Clin Nutr* 1999;70(suppl):512S–5S.

KEY WORDS Dietary fat, monounsaturated fatty acids, polyunsaturated fatty acids, saturated fatty acids, insulin resistance, Mediterranean diet, plant-based diet, heart disease, cardiovascular disease, coronary artery disease, diabetes, cancer, disease prevention

INTRODUCTION

Plant-based diets are gaining acceptance and popularity in the United States. There have always been people who followed so-called vegetarian food intake patterns, but that translated largely into eating no meat, or no red meat, chicken, or fish, rather than consuming diets that were truly plant-based, or composed primarily of vegetables, fruit, grains, and legumes. Vegetarian or plant-based diets are generally labeled as healthy compared with the typical American diet; this is based on the notion that plant-based diets are low in fat. The health benefits of low-fat diets are largely due to decreases in saturated fatty acid intake (1), yet many people who follow vegetarian diet patterns include foods from animals, such as milk products, butter, and eggs, all of which contain saturated fatty acids. In this article I explore the role of fatty acids from plants, which can be part of a healthful, plant-based diet.

In this country, the idea that low-fat, high-carbohydrate diets are essential for health has grown into an obsession, driven largely by efforts to reduce cardiovascular disease morbidity and mortality. Cardiovascular health is improving in the United States because dietary patterns are being altered, medical therapies are improving, and surgical techniques are being perfected. How much of this improvement can be attributed to diet is controversial (2).

MEDITERRANEAN DIETS

Over the past few years, a movement favoring plant-based diets, such as those consumed in countries surrounding the Mediterranean Sea, has become fashionable. This began with the epidemiologic observation that people who live in these countries have a lower incidence of cardiovascular disease when compared with most other Western nations (3). The diets of people living in Mediterranean countries differ from the typical US diet because they are largely plant-based, but not necessarily low-fat (4). The main fat-containing food identified in these dietary patterns is olive oil. The US Department of Agriculture (USDA) food guide pyramid places fats at the top with the admonition to "eat sparingly," and no foods are pictured or suggested (5). Promoters of plant-based, Mediterranean diets have reordered the food groups in the USDA food guide pyramid; their Mediterranean food pyramid has olive oil in the center with the suggestion to "consume daily" (6).

In addition to the favorable fatty acid composition of plant-based diets, the phytochemicals and antioxidant nutrients of diets high in fruits and vegetables are known to promote cardiovascular health (7, 8) and reduce the risk for certain types of cancer (9, 10). This is another important benefit of plant-based diets. For example, the avocado is a high-fat food that is also a source of nutrients associated with cardiovascular health and protection from cancer. Although the avocado is 83% fat, most of the fat is monounsaturated. One serving contributes, as a percentage of daily values, 4% of vitamins E, C, and B-6, 6% of folate, and 1 g dietary fiber (11). Despite its high fat content, the avocado is a good example of a plant-derived food that seems to be appropriate for a healthy diet.

DIETARY LIPIDS AND CARDIOVASCULAR RISK

We know that not all dietary fats and individual fatty acids cause similar changes in plasma concentrations of total choles-

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terol, LDL cholesterol, HDL cholesterol, and triacylglycerol. Mensink and Katan (12) showed 10 y ago that the reductions in plasma total-cholesterol concentrations achieved with low-fat diets could be matched by use of diets altered in the type of dietary fat. When unsaturated fatty acids replaced saturated fatty acids, the drop in HDL-cholesterol concentration and the rise in triacylglycerol concentration that were associated with low-fat, high-carbohydrate diets disappeared. After publication of these findings, many other dietary intervention studies along the same lines were published. Consequently, Mensink and Katan (13) published a meta-analysis of 27 studies in which carbohydrate had been substituted for fat to create a lower-fat diet. The authors were able to show, using meta-analysis, that when 1% of dietary carbohydrate is replaced by any type of dietary fat, HDL-cholesterol concentrations increase and triacylglycerol concentrations decrease. When the dietary fat is saturated, LDL- and total-cholesterol concentrations increase. But when the fat is composed of monounsaturated fatty acids (MUFA) or polyunsaturated fatty acids (PUFA), the increases in LDL- and total-cholesterol concentrations are attenuated.

In patients with type 2 diabetes and insulin resistance, dietary intervention studies comparing differing amounts of dietary fat have not all reached the same conclusions when looking for effects on HDL cholesterol. All studies showed an increase in triacylglycerol concentration when fat was replaced by carbohydrate. Studies in which energy from fat was reduced to 20–25% of total energy (14, 15) found a significant lowering of HDL-cholesterol concentration, but this did not occur when diets contained 13–15% of energy from total fat (16).

Katan et al (17) also examined the effects of individual dietary fatty acids on total-, LDL-, and HDL-cholesterol concentrations. Myristic acid (14:0) was associated with the most dramatic increases in total-, LDL-, and HDL-cholesterol concentrations, followed by palmitic acid (16:0) and lauric acid (12:0). *trans* Fatty acid (*trans* 18:1) was associated with increases in total- and LDL-cholesterol concentrations but a slight decrease in HDL-cholesterol concentration. However, stearic acid (18:0), oleic acid (18:1), and linoleic acid (18:2) were associated with lowering of total- and LDL-cholesterol concentrations. We know that fat-containing foods have a variety of fatty acids, but among the plant-based fats, oleic and linoleic acids predominate.

In another study, diets that followed the most stringent recommendations of the National Cholesterol Education Program (limiting fat intake to $<30\%$ of energy, saturated fat intake to $<7\%$ of energy, and cholesterol intake to <200 mg/d) were tested in a group of older adults (mean age: 61 y) (18). When two-thirds of the energy from fat was given as plant-based fats (corn, olive, or canola oils), plasma total- and LDL-cholesterol concentrations declined. Clearly, there are beneficial effects on cardiovascular risk factors when plant-based oils are substituted for animal-based fats in the diet. In this study, HDL-cholesterol concentration was reduced when the fat source was corn oil, but not when the diets contained canola or olive oils. The adverse effects on plasma lipids of lower-fat diets were diminished when subjects were allowed to choose foods ad libitum (19). Schaefer et al (19) noted an attenuation of the decrease in HDL-cholesterol concentration when subjects were losing weight during the low-fat diet phase compared with the weight-maintenance arm of the study.

Our understanding of the effects of individual fatty acids on chronic disease risk is relatively limited. Because fatty acids have been shown to affect not only the risk for cardiovascular disease, but also the risk for some cancers and other chronic diseases, it is important to learn more about the mechanisms by which these effects occur. Most of the available information pertains to how dietary fat and fatty acids affect coronary heart disease risk factors, because the effect of dietary fats on plasma lipids serves as a biological marker for assessing risk. Unfortunately, the lack of readily accessible biological markers for other diseases limits our understanding of the mechanisms by which specific dietary fats influence the development of noncardiac diseases.

Lyon Diet Heart Study

Unfortunately, no dietary intervention studies have investigated the metabolic responses to the amounts or types of fat in plant-based diets. The Lyon Diet Heart Study most closely represents a comparison of plant-based diets with diets low in fat and saturated fatty acids (20). The researchers studied the effects of a plant-based, low-saturated fat diet on secondary prevention of coronary heart disease in men and women after their first myocardial infarctions. Over 600 patients were randomly assigned to either the experimental group, which followed a Mediterranean-type diet, or a control group, which was instructed to follow a "heart-healthy" diet provided by the hospital dietitian or their personal physician. The experimental group was advised to consume more bread, root and green vegetables, and fish, and to eat fruit every day. Butter and cream were replaced with olive oil or rapeseed margarine that were supplied by the study.

Subjects on the experimental diet significantly decreased their intake of saturated fatty acids and linoleic acid, and increased their intake of oleic and linolenic (18:3n$-$3) acids compared with control subjects. The results of the plasma fatty acid analysis reflected the dietary changes in both groups. The experimental group had lower plasma stearic and linoleic acid concentrations and a higher plasma linolenic acid concentration than the control group. Although plasma cholesterol, triacylglycerol, and lipoprotein concentrations, body weight, and blood pressure were similar in the 2 groups at the end of 104 wk, there was a dramatic decrease in cardiac deaths and all cardiac events in the experimental group. These results were observed with a difference in total fat intake of only 2% of energy (32% in the control group and 30% in the experimental group). Clearly, other characteristics of the plant-based diets, beyond the total dietary fat intake and perhaps even the type of fatty acids, provided a cardioprotective effect. In addition to the studies described in this supplement, there is need for more research aimed at elucidating the health benefits of diets rich in grains, vegetables, and fruit.

INSULIN RESISTANCE

Over the past few years, attention has focused on a segment of the population that has inherited an insulin-resistant genetic trait. Although this trait does not readily manifest itself unless tolerance to dietary carbohydrate becomes abnormal, or when elevated plasma triacylglycerol or low HDL-cholesterol concentrations are studied, some investigators believe that it may be present in $\approx$25% of the population (21). People with this trait are at increased risk for cardiovascular disease, not because of elevated total- and LDL-cholesterol concentrations but because of increased fasting and postprandial plasma insulin concentrations, elevated fasting and postprandial plasma triacylglycerol concentrations, and low concentrations of HDL cholesterol. This topic is relevant here because all of the above-mentioned observations are worsened by diets with increasing carbohydrate and decreasing total fat, common characteristics of plant-based, "heart-healthy" diets (15). In addition, when people develop heart disease, the standard recommendation is a low-fat diet, which means that the deficit in energy previously supplied by fat will be replaced by additional dietary carbohydrate (22).

When people with insulin resistance consume test diets that are low in fat and enriched in carbohydrate, they experience an increase in newly synthesized intestinal VLDL-triacylglycerol concentrations as measured by the incorporation of retinyl esters from vitamin A given with the test meal (23). If plasma postprandial cholesterol ester concentration plays a role in atherogenesis, people with insulin resistance are at increased risk for heart disease when they follow a low-fat, high-carbohydrate diet. In this population, altering the type of dietary fat to favor plant-based fats rich in monounsaturated and polyunsaturated fatty acids is preferable to lowering total dietary fat and increasing dietary carbohydrate. In fact, many patients who have cardiovascular disease show signs of insulin resistance when tested for it (24). This is of concern because most cardiac rehabilitation programs recommend a low-fat, high-carbohydrate diet with the expectation that further deterioration of cardiovascular risk factors will be prevented.

Although this article focuses on types of dietary fats, in the context of discussing insulin resistance mention must be made of 2 recent epidemiologic reports that indicated that the risk of type 2 diabetes is increased in both men and women who have consumed diets high in starches that were readily digestible and had low fiber contents (25, 26). However, clinical studies that examined the plasma glucose and insulin responses to different types of dietary carbohydrate sources did not show differences depending on the carbohydrate sources (27, 28). As with many chronic diseases, type 2 diabetes and insulin resistance manifest themselves in humans as the result of genetic and environmental factors.

HUMAN FATTY ACID SYNTHESIS

Dietary fat is a major factor in determining the fatty acid composition of adipose tissue. Because the half-life of fatty acids in adipose tissue is ≈600 d, the fatty acid profile of adipose tissue reflects long-term dietary intake and may serve as an index of habitual dietary fatty acid intake over time (29). Studies were performed using magnetic resonance spectroscopy to compare the fatty acid composition of adipose tissue among vegans, who exclude all animal products; vegetarians, who exclude meat and fish but consume dairy products; and omnivores (30). Adipose tissue analysis revealed that the percentage of saturated fatty acids in vegan adipose stores was significantly less than that in vegetarians or omnivores, and the total polyunsaturated fatty acid content, but not the monounsaturated fatty acid content, was significantly higher in the adipose tissue from vegans. Analysis of the dietary intake of all 3 groups showed no difference in total energy intake or percentage of energy from dietary fat. Mean dietary fat intake, as a percentage of total energy intake, was 38–39%. Correlations were found between dietary fatty acid intake and adipose tissue composition for both saturated and polyunsaturated fatty acids. Total plasma cholesterol concentrations were significantly lower in the vegan group than in the omnivorous group, but there was no difference between the vegan and vegetarian groups. The vegetarian group had significantly lower LDL-cholesterol concentrations compared with the omnivorous group, but no differences were observed between the vegan and vegetarian groups in their lipid profiles. Rather surprisingly, no correlations were found between plasma lipid concentrations and dietary intake or between plasma lipid concentrations and fatty acid content of adipose tissue. The authors speculated that the discrepancy between plasma lipids and dietary or adipose tissue fatty acids may have been due to the large fluctuation of plasma lipid concentrations related to recent dietary intake or physiologic alterations (30).

If adipose tissue stores reflect dietary fat intake, what types of fatty acids are stored in adipose tissue when dietary fat intake is very low? By using indirect calorimetry in normal human volunteers who consumed high-energy, low-fat, high-carbohydrate diets, Acheson et al (31) found that net body fatty acid synthesis and fat storage did occur. More recently, diets providing 10% of energy from fat were compared with isoenergetic diets providing 40% of energy from fat in human dietary intervention studies of 25-d duration (32). The fatty acid composition of each diet was matched to the fatty acid composition of each subject's adipose tissue. When subjects were on the low-fat diet, about half of the VLDL triacylglycerol concentration was made up of newly formed fatty acids. The authors also noted that in the newly formed triacylglycerol particles, there was a decrease in 18:2 concentration and an increase in 16:0 concentration compared with the fatty acid composition of the diet. In contrast, during the higher-fat diet phase, the fatty acid composition of the VLDL triacylglycerol was similar to the composition of the diet. Isotopic studies showed that the increase in adipose tissue 16:0 content while on the low-fat diet was associated with increased de novo 16:0 synthesis.

CONCLUSIONS

On the basis of the data presented in this short review, it appears that the type of dietary fat associated with plant-based diets is not necessarily associated with increased risk for cardiovascular disease or other chronic diseases frequently linked to dietary fat intake. This article discussed studies that showed that the type of fat, rather than the amount of fat, seems to be more closely associated with risk factors for heart disease. In addition, there are groups in the population for whom low-fat diets increase certain risk factors for heart disease. And finally, we now know that fatty acid synthesis that occurs in people consuming low-fat diets (with energy content equal to their needs) results in the synthesis of triacylglycerol that is higher in saturated fatty acid content than is the diet itself. This indicates that diets very low in fat may worsen overall risk for heart disease.

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