PJCS Vol XXIX Nos 1 & 2 June/December 2004

Comparative Study of Coconut Oil, Soybean Oil, and Hydrogenated Soybean Oil[1]

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Abstract

The use of coconut oil in human nutrition and diet and its effect on the cholesterol level were investigated at the New England Deaconess Hospital, at Harvard affiliate. Based on the study, consumption of up to 50% of dietary fat as coconut oil does not significantly alter either total cholesterol or LDL cholesterol in otherwise healthy young men. Coconut oil when included in a well-balanced diet has no adverse effects, as evidenced by an improvement in the patient's TC/HDL ratio.

Introduction

Much controversy exists surrounding the metabolic effects of coconut oil (CNO) on the progression of atherosclerosis. Comprised predominately of medium-chain triglycerides, CNO may differ from long-chain saturated fats in its impact on plasma lipids. Studies indicate that chain length and degree of saturation may play a significant role in determining serum cholesterol levels and the deposition and utilization of fatty acids (Abumrad, et al. 1984; Reiser, et al. 1985; Longenecker 1939). McNamara, et al. (1987) have demonstrated that response to dietary cholesterol and fat are specific to each individual's feedback control mechanism.

This report indicates that most individuals are able to compensate effectively by maintaining unchanged plasma cholesterol levels with a high cholesterol intake and that only small changes result from alteration in the quality of fat. Additionally, Grundy's findings indicate that all saturated fatty acids, particularly stearic acid, do not have the same effect on plasma cholesterol (Grundy, et al. 1988).

The purpose of this investigation was to study the effects of medium- and long-chain fats on fasting plasma lipids to test the hypothesis that coconut oil will produce a neutral effect.

Materials and Methods

Males between the ages of 20 and 50 were studied to determine the effect of coconut oil, soybean oil, and hydrogenated soybean oil on lipid metabolism. Subjects were randomized in double-blind crossover design consisting of three 6-wk intervention phases with 4-wk washout periods in between. During each intervention phase, subjects replaced 50% of the fat in their diet with one of the three test oils. The intervention oils were supplied through specially prepared muffins. Subjects were asked to consume two muffins per day while following a moderate-fat diet, which was individualized to ensure weight maintenance. Total fat intake reflected the typical American intake of 37% of calories from fat.

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Recruitment for the study was accomplished via local newspaper ads, Harvard-related newspaper announcements, public service announcements, and posting of informational flyers. All inquiries were prescreened over the telephone to determine their suitability for meeting the study inclusion criteria. Approximately 600 volunteers were screened in this manner. Of these, 117 males were studied via laboratory testing to determine plasma total cholesterol and three-day food record analysis to determine baseline fat intake. Potential subjects were required to meet the eligibility criteria namely: 1) plasma total cholesterol of 180-270 mg/dl; 2) fat intake of e" 30% of total calories; 3) ability to commit to study visit schedule; and/or 4) ability to follow rigorous dietary protocol.

Among the subjects found to be eligible through laboratory and food record analysis, 38 (6 pilot subjects and 32 main trial subjects) of the 117 randomized into the Comparative Study of Coconut Oil, Soybean Oil, and Hydrogenated Soybean Oil provided data for analysis. Twenty-two subjects (including pilot subjects) have completed the 6-mo study; seven are currently involved in active intervention; and nine have dropped out due to inability to comply with the protocol requirements.

Demographics/Baseline Characteristics

Values for age (years), weight (pounds), height (inches), total cholesterol level (mg/dl), triglycerides (mg/dl), and lipoprotein phenotype were recorded for each individual as well as group means.

The mean age for the 22 completed subjects is 32 yr. The mean height and weight are 69.6 in (176.8 cm) and 171 lb (77.7 kg), respectively. Mean baseline total cholesterol value is 219 mg/dl. This number was derived from the average of three readings per subject taken during the 3-wk screening period.

Lipoprotein phenotyping was performed on all patients. The breakdown of the patterns for these 22 subjects was as follows: three subjects were found to have a normal lipoprotein phenotype pattern, 16 subjects were found to have a pattern of Type IIA, two were found to have a pattern of Type IIB, and one was found to have a pattern of Type IV.

Subjects were asked to keep their weight, exercise levels, alcohol consumption, and smoking habits stable over the duration of the 6-mo study because of the possible effects of these variables on lipid profile. These activities were monitored during each phase of the study.

The mean exercise level for the 22 completed subjects was 145.5 min/wk. Alcohol consumption averaged at 3.8 drinks/wk. Only two of the completed subject reported cigarette smoking g, at a rate of 50 and 70 cigarettes/wk (>1 pack/day for each subject).

Food Record Analysis/Fat Consumption Data

Subjects were taught detailed food record-keeping skills during the screening period. They were asked to record complete, accurate, and detailed sets of three-day food records while consuming their normal diet. Nutritional analysis was performed and fat consumption data were obtained for the 22 completed subjects via two sets of records (six day per subject) to provide an accurate overview of their weekly consumption patterns The mean daily total calorie intake for this group was 2,593 kcals/day. Their average total fat intake was 107 g/day, providing 37% of total calories from fat.

Dietary Adherence to Study Protocol

Dietary adherence to the study protocol has been measured by use of Product Usage Forms, Behavioral Compliance Surveys, and Food Record Analysis. During each dietary intervention phase, product usage forms were administered weekly to determine the subjects' consumption of research muffins. During the coconut oil intervention phase, the mean product usage was 98.29%; 98.66%, soybean oil phase; and 99.24% for hydrogenated soybean oil phase. No significant difference was found upon statistical analysis of these endpoints.

Behavioral Compliance Surveys were administered weekly during each of the three intervention phases to measure subject's self-assessment of his compliance to the study diet (consuming the intervention muffins, fat gram monitoring, and food record-keeping). The mean score during the coconut oil phase was 53.7; 54.5 during the soybean oil phase; and 54.1 in the hydrogenated soybean oil phase, with the highest possible score being 60.

Nine complete food records per subject were collected, from which mean daily calorie intake, mean daily total fat intake (grams), and percentage of calories derived from fat were calculated during each intervention phase.

Mean daily caloric intakes for the 22 subjects during the coconut oil, soybean oil, and hydrogenated soybean oil intervention phases were 2,506 kcals, 2,517 kcals, and 2,543 kcals, respectively. Mean daily total fat intake and percentage of calories derived from fat during the coconut oil intervention phase were 103 g and 38%, respectively. During the soybean oil phase, mean daily total fat intake was 106 g with 38% of calories from fat. During the hydrogenated soybean oil intervention phase, mean daily total fat intake was 105 g, with 37% of calories from fat. Body weight was monitored weekly throughout the study; in all cases patients' weights remained within 5 lbs (2.27 kg) of their baseline values.

Plasma Lipid Level

Total cholesterol, HDL cholesterol, LDL cholesterol, VLDL cholesterol, and triglyceride levels and the total cholesterol/HDL cholesterol ratio were obtained for each subject at multiple points during the baseline, intervention, and washout periods. The baseline values were obtained form blood samples taken during two consecutive screening visits. The values presented for the intervention phases represent the average of three readings taken at each of the last three visits during the 6-wk phase. The washout values represent one reading taken at the end of each 4-wek washout period.

Lipid analysis was performed at the Boston University School of Medicine Biophysics Laboratory under the supervision of Dr. Donald Small as follows: Following venipuncture, EDTA plasma samples were stored at -20°C until the day that assays were performed. HDL was isolated from plasma using dextran sulfate –Mg^{2+} (HDL cholesterol reagent, Sigma Chemicals, St. Louis, MO) method of precipitation. Total cholesterol measurements of HDL and plasma were determined using cholesterol oxidase (Sigma Chemicals) in a method modified from Allain following ethanolic KOH hydrolysis. Cholesterol ester hydrolase was omitted. Triglycerides were measure dusing a semi-enzymatic kit method (Sigma Chemicals kit #320-UV). Calculations for VLDL cholesterol and LDL cholesterol were as follows (units in mg/dl):

VLDL cholesterol = Tg/5
LDL cholesterol = Total cholesterol – (HDL cholesterol = Tg/5)

Results

Analysis of the three-day food records reveals excellent compliance to the protocol in terms of total fat consumption and percent calories der4ivedform fat. Additionally, patients' weight remained stable for the duration of the study, indicating good compliance to the prescribed caloric intake.

Comparisons of lipid profiles have revealed a statistically significant increase (p = .003) in HDL cholesterol during the CNO phase, which resulted in a significant improvement in the total cholesterol/HDL cholesterol (TC/HDL) ratio (p = .052). Significant improvements in TC/HDL were noted in SBO (P = .048) but not during the HSO (p = .089) dietary phase. It is well-known that the TC/HDL ratio is an important measurement for predicting cardiovascular risk, a lower number representing a lower risk. While replacement of both soy and coconut oil produced significant improvements in the TC/HDL ratio, these findings are most relevant for coconut oil due to its reputation for being hypercholesterolemic.

Discussion

The results presented in this paper represent the first step in the analysis of the large database generated by this study. Because of the complexity of human research, detailed multivariate analysis is needed, which is currently in progress. We plan to prepare a more detailed report and a scientific publication based on this study.

In the coming 3-4 months we expect to complete the statistical analysis, which include a multivariate assessment of dietary and metabolic determinants of the changes summarized in this report. Specifically, we will examine the effect of previous dietary intake (total calories, grams of fat, and percent of calories from fat) and previous blood lipid profile on the outcome. The data will be adjusted for age, level of physical activity, and fluctuations in body weight during the study period. A significant scientific contribution is expected to result for this study.

Although the results reported are preliminary, they establish the following:

1) The sample size of completed study subjects is sufficiently large to draw meaningful statistical conclusions. This has been facilitated by the experimental design in which all subjects underwent each of the three dietary treatments. Thus, inter-individual variability has essentially been reduced.

2) Two conclusions are solidly based. The first is that consumption of up to 50% of dietary fat as coconut oil does not significantly alter either total cholesterol or LDL cholesterol in otherwise healthy young men. More importantly, HDL levels seemed to increase significantly with CNO consumption. In fact, CNO was the only fat which raised HDL.

Although the mechanism by which coconut oil increases HDL is unclear, this observation is very significant since it raises the possibility of beneficial effects from coconut oil in subjects with increased cardiovascular risk due to low HDL levels. When combined with a moderate-fat diet (30% of calories), coconut oil may significantly improve blood lipid profiles in at-risk patients.

A significant impediment that could potentially hinder the recognition of coconut oil as a “healthy fat” is the argument that this saturated oil could worsen the blood lipid profiles of hypercholesterolemic individuals. Efforts should now be directed toward establishing the safety of coconut oil in this group of individuals. By showing an increase in HDL, data from the current study encourage investigating hypercholesterolemic individuals. We propose that this be done in two steps:

1) A trial of health individuals following a moderate-fat diet (30% of calories) in which 50% of the fat is derived form coconut oil.

2) Based on this, we will then be able to recruit hypercholesterolemic individuals for a similar trial of moderate-fat diet and coconut oil.

This approach will provide definitive proof of the safety of coconut oil for the general population. It may even promote coconut oil as a risk-reducing dietary constituent.

Conclusion

Coconut oil, constituting no more than 1% of the total fat intake of the average American diet, has received an unjust reputation of possessing hypercholesterolemic properties. From our data, it is clear that even with as great as a 50% replacement of coconut oil in the American diet, there are no overall adverse effects seen in the lipid profiles. Thus, coconut oil, included in a well balanced diet in reasonable amounts, has no adverse effects and appears even to be somewhat beneficial, as evidenced by an improvement in the TC/HDL ratio. The priority focus is to educate the public on reducing their total fat intake to no more than 30% of total calories, as recommended by the National Cancer Institute and Surgeon General. The real obstacle to be addressed is that the typical American eats too many calories. No single dietary fat can possibly be responsible for this nationwide dilemma.

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