PHYSIOLOGICAL EFFECTS OF LOW ERUCIC ACID RAPESEED OIL - REVIEW OF HELSINKI RAPESEED OIL STUDIES

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ABSTRACT

The effects of low erucic acid rapeseed oil, (low in saturated fatty acids, rich in mono-unsaturated fatty acids, α-linolenic acid and plant sterols), on serum lipoprotein cholesterol and triglyceride, plasma fatty acid and antioxidant levels were studied in two controlled human experiments. All together 98 apparently healthy subjects ate a rapeseed oil diet and another experimental diet in cross-over design for 3.5 or 6 weeks each. The low erucic acid rapeseed oil seems to have unique effects especially on serum total and LDL cholesterol, plasma fatty acid and antioxidant levels, compared to saturated fat diets or diets rich in mono- or polyunsaturated sunflower oil.

INTRODUCTION

The availability of new rapeseed oil plant cultivars with high oleic acid and very low erucic acid content in the oil inspired us to study the physiological effects of rapeseed oil, especially on the factors connected to risk of cardiovascular diseases. The so called "Helsinki rapeseed oil study 1" was in 1989 one of the first large human intervention studies with rapeseed oil carried out using a very strictly controlled study design. The purpose of the first study was to compare the effects of a monounsaturated rapeseed oil diet and a polyunsaturated sunflower oil diet. Study 1 was followed by "Helsinki rapeseed oil study 2" in which the effects of a rapeseed oil diet, rich in α-linolenic acid, was compared with another monounsaturated fat diet, low in α-linolenic acid.

EXPERIMENTAL

Subjects and designs

The intervention studies were carried out at the University of Helsinki, Division of Nutrition, in a controlled manner using blinded crossover designs (TABLE 1).

TABLE 1. Number and baseline characteristics of the subjects and some parameters of the study designs in the two studies.

Characteristic / parameter	Study 1	Study 2
Number of subjects (n)	59	39
Men (n)	29	20
Women (n)	30	19
Age, range (yr)	18-65	20-46
Body mass index, range (kg/m^2)	18-35	19-30
Serum cholesterol, range (mmol/l)	3.2-7.4	3.0-7.0
Serum HDL cholesterol, range (mmol/l)	0.6-1.9	1.0-2.2
Serum triglycerides, range (mmol/l)	0.3-2.8	0.4-2.0
Number of experimental diet periods	2	2
Length of diet periods (weeks)	3.5	6

Diets

In Study 1 almost all food (90 % of the energy) was given to the subjects. They were allowed freely to choose fat and cholesterol free foods in amount of 10 % of their energy intake. The subjects recorded the freely chosen foods in their diaries. In this study the evaluation of dietary intake was based on duplicate-portion analysis plus calculated contribution of freely selected items (TABLE 2).

TABLE 2. Mean energy, fat, fatty acid, and cholesterol content of the diets in Study 1.

Nutrient	Baseline diet, MF	Rapeseed oil diet, RO1	Sunflower oil diet , SO
Energy (MJ)	10.1	10.5	10.6
Total fat (% of energy)	35.8	37.8	37.7
Saturates	18.9	12.4	12.7
Monounsaturates	11.0	16.2	10.2
Polyunsaturates	3.7	7.6	13.3
Linoleic acid, C18:2(n-6)	3.2	5.5	12.7
α-Linolenic acid, C18:3(n-3)	0.4	2.1	0.4
Cholesterol (mg/day)	354	360	315

In Study 2, the diets were modified by replacing fatty foods with experimental foods and by advice to restrict some of the foods normally used by the subjects. The subjects received weekly portions according to their energy level of margarine, food oil, salad dressing, bread, cakes and cookies enriched with the test oils. Food consumption of the subjects was evaluated in this study by dietary records (3 days' records at baseline, 7 days' records on the experimental diets) (TABLE 3).

TABLE 3. Mean energy, fat, fatty acid, and cholesterol content of the diets in Study 2.

Nutrient	Baseline diet, HAB	Rapeseed oil diet, RO2	High oleic acid sunflower oil diet ,TSO
Energy (MJ)	9.5	10.0	10.2
Total fat (% of energy)	33.0	40.8	39.0
Saturates	13.9	11.8	11.2
Monounsaturates	11.2	17.8	17.2
Polyunsaturates	5.1	8.5	8.3
Linoleic acid, C18:2(n-6)	4.2	6.1	7.9
α-Linolenic acid, C18:3(n-3)	0.6	2.2	0.3
Cholesterol (mg/day)	348	270	276

Fish consumption was restricted in both experiments, and the intakes of eicosapentaenoic acid, C20:5(n-3), and docosahexaenoic acid, C22:6(n-6), on the experimental diets were on average ≤30 mg/day and ≤60 mg/day, respectively.

Blood sampling and analysis

Fasting blood samples were taken during the last week of each period in both studies. Ultracentrifugation was used to separate the lipoprotein fractions, serum and lipoprotein cholesterol and triglycerides were analyzed enzymatically, apoproteins were quantified by immunoturbidimetry, plasma fatty acids were analyzed by GC, and plasma antioxidants by HPLC. All these laboratory analyses were carried out at the National Public Health Institute.

RESULTS

Serum lipids and lipoproteins

In Study 1, both test diets reduced serum total cholesterol (TC) and LDL cholesterol (LDL-C) levels from baseline, but the RO1 diet more than the SO diet (TC: - 15% vs. -12%, $p<0.01$; LDL-C: -23% vs. -17%). In Study 2, the effects of RO2 diet and TSO diet on TC and LDL-C did not differ (TC: -10% vs. -9%; LDL-C -22% vs. -21%). Total HDL-C was unaffected on all experimental diets compared to baseline levels, but the RO1 diet resulted in a more favorable HDL2-C/LDL-C - ratio (0.43 vs. 0.39, $p<0.01$) and a higher apolipoprotein A-I/B ratio (3.0 vs. 2.4, $p<0.001$) than the SO diet.

Plasma fatty acids

The proportions of plasma C18:3(n-3) and C20:5(n-3) were higher at the end of RO1 diet (in plasma cholesterol esters, CE: 1.5% and 1.3%) and RO2 diet (CE: 1.2% and 1.1%) compared to SO diet (CE: 0.3% and 0.6%) and TSO diet (CE: 0.4% and 0.6%). The proportions of plasma C22:6(n-3) levels did not differ between the experimental diets.

Plasma antioxidants

The effects of the RO diets on plasma α-tocopherol levels did not differ compared to SO and TSO diets, although the α-tocopherol content of SO and TSO diets were higher than of RO diets. The plasma γ-tocopherol levels increased or did not change on the RO diets compared to baseline levels (RO1: from 0.7 mg/l to 1.7 mg/l, $p<0.001$; RO2/women: 1.33 mg/l vs. 1.37mg/l, NS; RO2/men: from 0.7 to 1.1 mg/l, $p<0.01$). In contrast, the plasma γ-tocopherol levels decreased on the SO diet (from 0.7 mg/l to 0.4 mg/l, $p<0.001$) and the TSO diet (from 1.4 mg/l to 0.6 mg/l, $p<0.01$) compared to baseline levels.

ACKNOWLEDGEMENTS

The authors thank Martijn Katan and Ronald Mensink for help in setting up the first study, and the subjects for cooperation. The experimental fats were kindly supplied by Finnish Unilever, Van den Bergh Foods, and some of the other foods by the Finnish food industry. These studies were supported by grants from The Food Research Foundation, The Sigrid Jusélius Foundation, The Academy of Finland, The Ministry of Agriculture and Forestry, The Finnish Cultural Foundation, The Yrjö Jahnsson Foundation, The Wihuri Foundation, The Finnish Foundation for Cardiovascular Research, and The Orion Corporation Research Foundation.

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