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Corn oil improves the plasma lipoprotein lipid profile compared with extra-virgin olive oil consumption in men and women with elevated cholesterol: Results from a randomized controlled feeding trial

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BACKGROUND: Restricted intakes of saturated and trans-fatty acids is emphasized in heart-healthy diets, and replacement with poly- and monounsaturated fatty acids is encouraged.

OBJECTIVE: To compare the effects of polyunsaturated fatty acid–rich corn oil (CO) and monounsaturated fatty acid–rich extra-virgin olive oil (EVOO) on plasma lipids in men and women (N = 54) with fasting low-density lipoprotein cholesterol (LDL-C) ≥130 mg/dL and <200 mg/dL and triglycerides (TG) ≤350 mg/dL.

METHODS: In a double-blind, randomized, crossover design (21-day treatments, 21-day washout between), 4 tablespoons/day CO or EVOO were provided in 3 servings study product/day (muffin, roll, yogurt) as part of a weight-maintenance diet (~35% fat, <10% saturated fat, <300 mg cholesterol). Subjects ate breakfast at the clinic every weekday throughout the study. Lunches, dinners, and snacks (and breakfasts on weekends) were provided for consumption away from the clinic.

RESULTS: Baseline mean (standard error) lipids in mg/dL were: LDL-C 153.3 (3.5), total cholesterol (total-C) 225.7 (3.9), non–high-density lipoprotein (non–HDL)-C 178.3 (3.7), HDL-C 47.4 (1.7), total-C/HDL-C 5.0 (0.2), and TG 124.8 (7.2). CO resulted in significantly larger least-squares mean % changes (all $P < .001$ vs EVOO) from baseline in LDL-C −10.9 vs −3.5, total-C −8.2 vs −1.8, non–HDL-C −9.3 vs −1.6, and total-C/HDL-C −4.4 vs 0.5. TG rose a smaller amount with CO, 3.5 vs 13.0% with EVOO ($P = .007$). HDL-C responses were not significantly different between conditions (−3.4 vs −1.7%).

CONCLUSION: Consumption of CO in a weight-maintenance, low saturated fat and cholesterol diet resulted in more favorable changes in LDL-C and other atherogenic lipids vs EVOO.

Trial Registration: ClinicalTrials.gov identifier: NCT01925716.

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Introduction

Corn oil (CO) contains the highest naturally occurring phytosterol levels of the refined vegetable oils (0.97 g/100 g oil per the US Department of Agriculture National Nutrient Database for Standard Reference), and is rich in polyunsaturated fatty acids (PUFA).[1,2] Restriction of intakes of saturated fatty acids (SFA) and trans-fatty acids is emphasized in cholesterol-lowering, heart-healthy diets, whereas consumption of unsaturated fatty acids is emphasized.[3–5]

PUFA, in place of SFA or carbohydrates, has been shown to lower the plasma low-density lipoprotein cholesterol (LDL-C) concentration and to be associated with reduced risk for coronary heart disease (CHD) in prospective cohort studies.[6–8] The Mediterranean dietary pattern, high in monounsaturated fatty acids (MUFA)-rich olive oil, has also been associated with reduced CHD risk in epidemiological and clinical studies,[9–11] and, when substituted for SFA or carbohydrates, MUFA significantly reduces LDL-C without lowering high-density lipoprotein (HDL)-C.[7,12,13] The degree of unsaturation that is most effective for providing beneficial lipid changes and protection from CHD is controversial.[14–16]

It is often underappreciated that, although food sources, including dietary oils, may be rich in 1 type of fatty acid, they are not 100% SFA, MUFA, or PUFA. Thus, it is important to consider the effects of specific food choices, particularly with regard to the effects of substitution of 1 food or food component for another. The present, single-center, randomized, controlled, double-blind, 2-period, crossover feeding trial compared the effects on lipoprotein lipids of 2 mostly unsaturated dietary oils, CO and extra-virgin olive oil (EVOO), incorporated into a weight-maintenance diet containing ~35% of kcal from fat, <10% SFA, and <300 mg/d cholesterol in men and women with hypercholesterolemia at a single clinical research center (Biofortis Clinical Research, Addison, IL).

Methods

Study design

This study was conducted according to Good Clinical Practice Guidelines, the Declaration of Helsinki (2000), and the United States 21 Code of Federal Regulations (ClinicalTrials.gov identifier: NCT01925716). The study protocol and informed consent documents were approved by an institutional review board (Quorum Review IRB, Seattle, WA). A signed informed consent form and authorization for disclosure of protected health information were obtained from all subjects before protocol-specific procedures were carried out. Staff and subjects remained blinded to treatment throughout the trial.

Treatments

The study included 2 21-day treatment periods and a 21-day washout between treatments. During the treatment periods, 4 tablespoons per day (~54 g) of CO (528 mg phytosterols, 29.7 g PUFA) or EVOO (120 mg phytosterols, 5.6 g PUFA) were provided in 3 servings of study products per day (muffin, dinner roll, yogurt) as part of a weight-maintenance diet. The fatty acid and sterol compositions of the CO and EVOO as determined by Covance Laboratories (Madison, WI) are shown in Tables 1 and 2, respectively, and the nutrient compositions of the study products are presented in Table 3. Subjects reported to the clinic on Monday through Friday during both treatment periods for breakfast, including 1 serving of study product, between 0630 and 0930 AM. Subjects were provided lunch, dinner, and a snack, including 2 additional servings of study product, 1 of which was consumed with lunch and 1 with dinner, for consumption away from the clinic. Meals for Saturday and Sunday were dispensed on Fridays for consumption outside the clinic.

Meal plans were determined for the subjects based on energy needs using the Mifflin-St Jeor equation[17] to estimate resting energy expenditure, and summed with the average estimated energy expended in physical activity as assessed by the Stanford 7-day activity questionnaire.[18] A range of menu plans in 200-kcal increments from 1800 to 3600 kcal/d was created. The diets were designed to provide ~35% energy/d from fat (<10% SFA and <300 mg cholesterol), ~15% energy/d from protein, and ~50% energy/d from carbohydrate (with total daily fiber intake ~15 to 20 g/d). All foods in the rotating menus were identical in the 2 treatment conditions with the exception of the oils used to prepare the study foods (dinner roll, muffin, and yogurt). The average daily energy and nutrient intakes for the rotating menus were analyzed using Food Processor SQL Nutrition Analysis and Fitness Software (version 10.4.0, ESHA Research, Salem, OR). Subjects were also given a list of non-caloric beverages for ad libitum consumption. They were instructed to consume all of the study foods in their entirety and to avoid consuming any additional food or nonspecified drink items. In the event that a subject consumed a nonstudy food or caloric beverage, he or she was instructed to record the intake of the food/beverage item in a provided notebook and return to the clinic the uneaten portion of the nonstudy food or the label of the nonstudy item.

Compliance with the dietary instructions was evaluated by the study staff according to the returned food items from the lunch and dinner meals and snack; study product compliance was recorded as the percentage of scheduled intakes of study products consumed. Body weight was assessed weekly during each treatment period, and meal plans were adjusted, as needed, to ensure each subject maintained a stable body weight. Subjects were also instructed to maintain their usual physical activity level