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A pecan-enriched diet increases γ-tocopherol/cholesterol and decreases thiobarbituric acid reactive substances in plasma of adults

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Abstract

Consumption of nuts is associated with a reduced risk of coronary heart disease, and dietary intervention studies incorporating pecans show improved lipid profiles. The unsaturated fats in pecans are protected against oxidation by the high concentrations of γ-tocopherol and polymeric flavanols. The aim of this study was to determine whether plasma concentrations of tocopherols and measures of antioxidant capacity and of oxidative stress are affected by incorporation of pecans in the diet. In a randomized, controlled, crossover feeding study, 24 subjects were assigned to 2 diets, each for 4 weeks: a control diet and a pecan-enriched (20% of energy) diet. Cholesterol-adjusted plasma γ-tocopherol increased by 10.1% ($P < .001$), α-tocopherol decreased by 4.6% ($P < .001$), and malondialdehyde concentrations measured as thiobarbituric acid reactive substances decreased by 7.4% ($P < .05$) on the pecan diet. No changes were observed for ferric-reducing ability of plasma or Trolox equivalent antioxidant capacity values. These data provide some evidence for potential protective effects of pecan consumption in healthy individuals.

Keywords: Pecans; Humans; α-Tocopherol; γ-Tocopherol; TBARS; FRAP; TEAC

1. Introduction

Consumption of nuts has been associated with a reduced incidence of cardiovascular mortality [1-4]. Controlled-feeding trials with pecans [5,6] and other nuts [7-10] have shown improved lipid profiles with a decrease in total and low-density lipoprotein (LDL) cholesterol and in triglycerides in healthy and hyperlipidemic individuals. These results are attributed to the fatty acid contribution of nuts, low in saturated fat and high in mono- and polyunsaturated fat. Further benefits of nut consumption may result from their content of tocopherols and polyphenolic substances. These substances are of interest because of their potent antioxidant capacity and possible protective effect on human health.

Pecans (*Carya illinoensis*), now a popular American tree nut, were an early staple of Native Americans who inhabited the Southern regions of the country. The main fatty acids in pecan nuts are oleic acid and linoleic acid, contributing 56.4% and 18.9% of the total lipid, respectively [11]. Although the favorable effects of pecan intake on the serum lipid profile have been shown, there has been very little investigation into the contribution of nuts to antioxidant protection. The most important natural antioxidants in plant fats are tocopherols, and pecans are a rich source of γ- and a poor source of α-tocopherol, containing 24.4 and 1.4 mg per 100 g of nut, respectively. Pecans also contain complex flavanoid substances, especially proanthocyanidins, or condensed tannins, which are monomers and polymers of the flavan-3-ols unit [12,13]. These substances are recognized for their effective inhibition of lipid oxidation in foods and possibly in biological systems.

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Previously, we showed that a pecan-enriched diet improved serum lipids in human subjects [5]. The aim of this study was to evaluate the effect of consuming a pecan-rich diet on plasma α- and γ-tocopherol concentrations and on measures of antioxidant capacity and lipid peroxidation in healthy persons.

2. Methods and materials

2.1. Subjects

Twenty-four healthy volunteers (14 men and 10 women) were enrolled in this study. The subjects were between 25 and 55 years of age (mean ± SD, 38.1 ± 8.8) and their mean body mass index was 25.4 ± 5.0 kg/m^2 and did not change during the study. All study participants were in good health with no history of hypertension, heart disease, or other metabolic disease, and were not taking medications known to affect serum cholesterol. Subjects were within reference ranges on clinical laboratory tests, including measurement of triacylglycerol (1.23 ± 0.67 mmol/L), total cholesterol (5.04 ± 0.84 mmol/L), and LDL cholesterol (3.27 ± 0.65 mmol/L). All subjects attended detailed informational sessions and gave written informed consent to their participation in the study. The study was approved by the Institutional Review Board of Loma Linda University.

2.2. Study design, dietary intervention, and study timeline

A detailed description of the study procedures has been published elsewhere [5]. Briefly, this was a randomized, single-blind, crossover, controlled-feeding trial. After an initial 2-week run-in phase, the subjects were randomly assigned to consume either a control diet or a pecan-enriched diet for 4 weeks. The groups then reversed diets and continued for another 4 weeks. Initially, subjects were assigned to a specific energy level based on height, weight, age, and physical activity. Thereafter, subjects were regularly weighed and energy levels were adjusted to maintain body weight. All meals were obtained from research staff. Sunday through Friday breakfast and dinner were consumed at the U.D. Register Nutrition Research dining facility under the supervision of a senior researcher. Subjects picked up lunch at breakfast and evening snack at dinner, and Saturday meals were frozen and/or packed in ice for home consumption. All foods were weighed to the nearest 0.5 g.

Nutrient composition of study diets is shown in Table 1. The control diet adhered to the recommendations of a heart-healthy diet [14]. The pecan diet used the same food items as the control diet except that 20% of energy was provided by pecans. Each food item of the control menu was proportionately scaled down by 20% (ie, total energy was reduced by 20%) to accommodate the pecans. Eight weekday menus and 2 weekend menus were used on a rotating basis. The nutrient content of the study diets was calculated by using the Nutrition Data System for Research software developed by the Nutrition Coordinating Center of the University of Minnesota version 5.0 (Minneapolis, Minn). The pecan diet was substantially higher in oleic acid, linoleic acid, and γ-tocopherol than the control diet.

Table 1
Nutrient content of the control and pecan supplemented diets provided to participants per 8400 kJ

	Control diet	Pecan diet
Energy (kJ)	8400	8400
Total fat		
(g/d)	62.4	91.6
(% Energy)	28.1	41.2
Saturated fat		
(g/d)	20.6	20.1
(% Energy)	9.27	9.05
Monounsaturated fat		
(g/d)	24.1	42.9
(% Energy)	10.85	19.31
Polyunsaturated fat		
(g/d)	13.1	22.9
(% Energy)	5.90	10.31
Linoleic acid		
(g/d)	11.6	21.2
(% Energy)	5.22	9.54
α-Linolenic acid		
(g/d)	1.3	1.6
(% Energy)	0.59	0.72
Protein		
(g/d)	65.9	58.0
(% Energy)	13.18	11.6
Carbohydrate (g)	306	253
Dietary fiber (g)	22.0	23.1
Dietary cholesterol (mg)	165	132
α-Tocopherol (mg)	6.76	6.22
γ-Tocopherol (mg)	13.7	25.1

Values were obtained by using the Nutrition Data System for Research (NDS-R) (Version 5.0, 2004, University of Minnesota Nutrition Coordinating Center, Minneapolis, MN). Averages were calculated from 8 weekday menus and 2 Saturday (take home) menus.

2.3. Sample collection and biochemical measurements

Blood samples were collected after the subjects had fasted overnight at the end of each of the 4-week experimental periods. Plasma and serum were prepared within 60 minutes of collection and were immediately portioned into aliquots and stored at −80°C.

Concentrations of α- and γ-tocopherol in plasma were measured by using normal-phase high-performance liquid chromatography (HPLC) with fluorometric detection (excitation, 292 nm; emission, 330 nm) as described by Kramer et al [15]. Plasma proteins were precipitated with ethanol and samples were extracted with hexane and injected onto a silica column (Supelcosil LC-Diol, 5 μm, 250 × 4.6 mm; Supelco Inc., Bellefonte, Penn) using hexane-isopropanol (99:1, vol/vol) as a mobile phase at a flow rate of 1 mL/min.

The thiobarbituric acid (TBA) assay is commonly used to measure malondialdehyde (MDA). Because of the lack of specificity of this assay in biological systems, results are expressed as thiobarbituric acid reactive substances (TBARS). Plasma TBARS were measured by using HPLC