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Cardioprotective effects of chocolate and almond consumption in healthy women

Sara B. Kurlandsky, PhD*, Kim S. Stote, RD, MPH, PhD
Department of Nutrition and Hospitality Management, Syracuse University, Syracuse, NY 13244, USA
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Abstract

The primary objective of this study was to identify potentially synergistic or additive effects of combining consumption of dark chocolate with almonds as part of a low-fat diet on circulating levels of serum lipids and inflammatory markers: intercellular adhesion molecule (ICAM), vascular adhesion molecule, and high-sensitivity C-reactive protein. A 6-week, 4-armed parallel design was used; 49 healthy normocholesterolemic women participated. Subjects were randomized to 1 of 3 treatments: chocolate (41 g/d), almonds (60 g/d), chocolate and almonds, or control (no chocolate or almonds). All subjects followed the National Cholesterol Education Program Therapeutic Lifestyle Changes diet. All subjects improved dietary intakes in accordance with guidelines, and no subjects gained or lost weight. Serum cholesterol concentrations showed no changes after 6 weeks; however, triacylglycerol levels were reduced by approximately 21%, 13%, 19%, and 11% ($P < .05$), in the chocolate, almond, chocolate and almond, and control groups, respectively. Circulating ICAM levels decreased significantly by 10% in the treatment group consuming chocolate only ($P = .027$). No significant changes were observed for vascular adhesion molecule and high-sensitivity C-reactive protein levels in any treatment group. No synergistic or additive effects were observed when both products were consumed. In conclusion, consumption of chocolate and almonds as part of the Therapeutic Lifestyle Changes diet for 6 weeks showed no harmful effects in healthy women; all dietary modifications improved serum triacylglycerol levels, and consumption of chocolate reduced levels of circulating ICAM.

Keywords: Chocolate; Almonds; Adhesion molecules; Serum lipids; Human intervention

1. Introduction

Underlying diet-mediated disease prevention is the notion that dietary constituents can reduce disease risk by modulating complex processes associated with etiology and progression. Epidemiologic studies have associated certain dietary patterns with reduced risk for a variety of chronic diseases, including cardiovascular disease (CVD). This association was particularly evident in Mediterranean regions of the world, where dietary patterns reflected high consumption of fresh fruits and vegetables, high fiber grains, seafood, and monounsaturated fatty acids (MUFA) [1]. For example, diets high in saturated fatty acids (SFA) have been positively associated with CVD risk, whereas foods high in MUFA, such as nuts or olive oil, have been inversely associated with risk [1-5]. Other food components unrelated to fat, such as plant polyphenolics, have shown an inverse association with CVD risk [6,7]. Results of many studies suggest that these foods or food components appear to work through different mechanisms of action, and they may present different outcomes that would address multiple risk factors: decreased absorption of dietary cholesterol, low-density lipoprotein (LDL) cholesterol lowering, improved endothelial function, or reduced inflammation. Dark

* Corresponding author. Tel.: +1 315 443 2269; fax: +1 315 443 2735.
E-mail address: sbkurlan@syr.edu (S.B. Kurlandsky).

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chocolate has shown promise with respect to decreasing platelet reactivity, increasing vasodilation of arteries, improved antioxidant capacity and protection against LDL oxidation, and improved insulin sensitivity and blood pressure [8-20]. Chocolate consumption has shown neutral responses with respect to reducing cholesterol levels and biomarkers of inflammation, such as the cytokines interleukin 1β, interleukin 6, tumor necrosis factor α, and high-sensitivity C-reactive protein (hsCRP) [14,21]. Dark chocolate is high in flavonoids, including the monomers catechin and epicatechin, as well as oligomeric procyanidins, which may explain antioxidant and anti-inflammatory responses observed [22]. Chocolate also contains fat in the form of cocoa butter, which is composed of a mixture of stearic (35%), palmitic (25%), and oleic (35%) acids, and a small amount of linoleic acid [22]. The high content of SFA has raised concerns about chocolate consumption and LDL cholesterol; however, the high proportion of oleic acid and the potential for conversion of stearic acid to oleic acid in the body may help attenuate negative fatty acid effects [23].

Nuts have also been shown to have cardioprotective effects, especially in lowering serum lipids. Low-density lipoprotein cholesterol reductions of 10% to 15% have been observed in clinical studies where walnuts, almonds, macadamias, hazelnuts, pecans, or peanuts were incorporated into the diet [24-34]. Almonds, in particular, have also been shown to reduce LDL oxidation and serum lipids [29,33]. Almonds contain high levels of fat (52% by weight) but have a favorable fatty acid profile (68% MUFA, 22% polyunsaturated fat [PUFA], and 10% SFA). Almonds also have high levels of α-tocopherol and fiber and contain other potentially favorable components including flavonoids [35].

Jenkins et al [36-38] recently presented evidence that a low-fat diet portfolio containing foods high in soluble fiber, nuts, soy, and plant polysterols consumed together would generate additive or synergistic effects with respect to lowering LDL cholesterol levels and measures of inflammation. To our knowledge, few other intervention studies have looked at a combination of foods on reduction of CVD risk, especially snack foods.

The objective of the present study was to look at the effects on selected CVD risk factors of combining 2 popular snack foods, chocolate and almonds, as part of the Therapeutic Lifestyle Changes (TLC) diet from the National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III) in healthy individuals. Our specific aims were to identify potential synergistic or additive benefits derived from eating both dark chocolate and almonds; to identify additional beneficial effects from either food not previously reported; and to demonstrate that these foods could be incorporated into the TLC diet without adverse effects. We present data on the following risk factors: circulating levels of serum lipids and the inflammatory biomarkers hsCRP, intercellular adhesion molecule (ICAM), and vascular adhesion molecule (VCAM).

2. Methods and materials

2.1. Subjects

Healthy men and women, ages 22 to 65 years, were recruited by community and campus-directed email advertisements. For inclusion into the study, subjects were required to have baseline serum total cholesterol levels ranging between 4.1 to 7.8 mmol/L (160-300 mg/dL); no previous history of hypertension, artherosclerosis or metabolic diseases; no use of lipid-lowering medication or dietary supplements; and a willingness to maintain current weight and adhere to typical exercise patterns throughout the study. Stable regimens of oral contraceptives and hormone replacement therapy (HRT) were allowed. Exclusion criteria included known allergy to either nuts or chocolate, smoking, alcohol intake greater than 2 oz/d, and body mass index (BMI) higher than 34 kg/m^2. The institutional review boards of Syracuse University and the State University of New York Upstate Medical University approved the study protocol, and all subjects gave written informed consent before participation in the study.

2.2. Study design

The study was a 6-week, 4-armed, controlled parallel design, as illustrated in Fig. 1. After a four-week diet lead-in/screening period, subjects were randomized to 1 of 3 treatments and a control group: treatment group 1 consumed a small amount of dark chocolate (41 g) daily with a self-selected diet; treatment group 2 consumed a small amount of almonds (60 g) daily with a self selected diet; treatment group 3 consumed both dark chocolate and almonds daily with a self-selected diet; and the control group consumed a self-selected diet avoiding nuts and chocolate. The dark chocolate was provided in the form of a candy bar (Dove Silky Dark Chocolate, 1.3 oz, M & M, Division of Mars, Inc, Hackettstown, NJ). The self-selected diet followed by all subjects was based on guidelines from

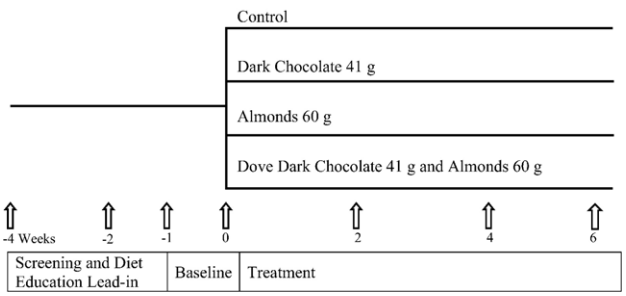

Fig. 1. Schematic of study treatment assignments and protocol using a parallel treatment design. All participants received extensive diet education and acclimated to the NCEP ATP III TLC diet for 4 weeks during the study screening process. Participants were randomized to treatment groups at week 0; the treatment period was 6 weeks. Participants met with investigators at study visits (indicated by arrows) every 2 weeks; at study visits, weights were assessed, 3-day diet records were reviewed and collected, adverse events were noted, and questions and concerns were discussed.