Olive Oil, the Mediterranean Diet, and Cardiovascular Health

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The Mediterranean Diet

Inhabitants of Southern European and North African regions surrounding the Mediterranean Sea have a longer life expectancy and lower risk of chronic diseases than in other regions of the world.[1] It is believed that the diet and lifestyle of these Mediterranean populations have led to decreased rates of cancer, diabetes, and heart disease. The 1968 Seven Countries Study concluded that coronary heart disease was not a major indicator of mortality in men who inhabited the Greek island of Crete.[2] The occurrence of myocardial infarction, fatal and nonfatal, was 26 in 10,000 Cretans, in contrast to the Northern Finland cohort, where the rate was 1,074 in 10,000.[3] Although the Mediterranean diet varies somewhat regionally, its nutritional model of whole grains, vegetables, fruits, red wine, and olive oil is believed to contribute to decreased rates of coronary heart disease. A recent survey in the region of Girona, Spain, of 3,179 subjects found that adherence to the traditional Mediterranean diet was inversely associated with body mass index and obesity, major risk factors for heart disease.[4] Health benefits of the Mediterranean diet have precipitated studies on the effects of its various components, specifically extra virgin olive oil (EVOO).

Mediterranean countries have maximized their use of olive oil, becoming the largest consumers, producers, and exporters of both olives and olive oil. Together they manufacture approximately 90% of the total olive oil produced. Because of olive oil's role as the primary source of fat intake, the Mediterranean diet is high in monounsaturated fatty acids (MUFA), specifically oleic acid, and low in saturated fatty acids (SFA).[5] Studies affirm that dietary *cis*-MUFA have a greater antiatherosclerotic effect than SFA and are comparable with the effects of polyunsaturated fatty acids (PUFA) on cardiovascular risk factors.[6,7]

Worldwide, the Japanese and Cretan populations have the lowest SFA intake, 3% to 8% and 8% of total fat consumption, respectively. The Japanese and Cretan cohorts in the Seven Countries Study had the lowest ischemic heart disease (IHD) mortality rates.[8] Cretans exhibited a low rate of IHD and low plasma cholesterol levels despite their high fat diet (33% to 40% of caloric intake).[9] For Cretans, olive oil provides approximately 29% of the total dietary energy and this accounts for the island's unusually high MUFA-to-SFA ratio.[10] Conversely, Finland, with the world's highest SFA intake at 20% of their diet, has the highest rates of IHD mortality, with a rate of 132.2 IHD deaths per 100,000 deaths, and Japan and Greece have a rate of 28.6 and 64.7, respectively[11] (Fig. 1A, 1B). Per capita olive oil consumption can be loosely correlated to rates of IHD mortality, with the exception of France and Japan.

Although a variety of factors play a role in heart disease mortality rates, including differing regional diets, health care quality, and socioeconomic status, it is generally established that the Finnish diet of fatty red meats, butter, and bread is highly conducive to heart disease when compared with the Mediterranean diet. Fat- and calorie-dense foods support the physically demanding Finnish lifestyle of living and laboring in cold, wet conditions. Other factors, including genetic differences, stress levels, and Finland's arduous work environments, can contribute to these observed health disparities. In contrast, whole grains, fresh vegetables, red wine, and olive oil are sufficient in the temperate Mediterranean basin and, as research now shows, this dietary complex might contribute to a decreased risk of cardiovascular disease. Epidemiologic and biologic evidence also suggest that moderate consumption of red wine has an important role in low rates of IHD because of the antioxidative nature of its resveratrol component. It should be noted also, that although diet does influence cardiovascular health, a host of confounding variables, such as lifestyle, exercise, stress level, environment, and genetics, play a role in the health of those in the Mediterranean region.

The Japanese and Mediterranean diets and lifestyle are remarkably similar, and both emphasize physical activity. The core components of the Japanese and Mediterranean diets are cereals; vegetables such as beans and nuts; and lean meat, such as fish (Fig. 2A, 2B). Although the Japanese population only has a per capita consumption of olive oil of 0.24 kg per year, vegetables and vegetable oils are integral to the diet.

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Abbreviations and Acronyms

CM = chylomicrons
EVOO = extra virgin olive oil
ICAM-1 = intercellular adhesion molecule-1
IHD = ischemic heart disease
IMT = intima-media thickness
MUFA = monounsaturated fatty acids
NO = nitric oxide
PAI-1 = plasminogen activator inhibitor-1
PUFA = polyunsaturated fatty acids
SFA = saturated fatty acids
VCAM-1 = vascular cell-adhesion molecule-1

approved a new pyramid incorporating elements of the Japanese and Mediterranean diets (Fig. 2C). The previous 1992 Food Pyramid was revised to emphasize regular moderate consumption of olive oil and red wine, encourages daily exercise, and distinguishes between good and bad fats, and whole and processed grains. This article intends to review the data that links olive oil to decreased rates of heart disease risk factors, including arteriosclerosis, high blood pressure, and hypercholesterolemia.

From olive to oil

The Mediterranean region is positioned at the convergence of the hot Saharan and the cool Atlantic climates. This results in dry summers and mild winters, which provide a favorable extended growing season for vegetables and fruits.[12] The region's substantial sun exposure has been correlated to the high antioxidant content in plants. Vegetation native to the area has augmented its production of antioxidants to defend against reactive oxygen species produced during photosynthesis. Recent epidemiologic studies have established an inverse relationship between intake of fruit and vegetable−based antioxidants and mortality rates from chronic diseases.[13]

The most widespread species of olive is the *Olea europaea* and its genus includes 35 species of evergreen shrubs and trees.[14] Olive trees have an unusual ability to develop roots from temporary buds at the lower end of their trunks, are resistant to severe weather conditions, and are able to grow in infertile soil. Olive fruit maturation spans several months and its taste and chemical composition is dependent on growing conditions, including latitude, water availability, and temperature. The maturation, harvesting, and developing process of olives and olive oil is heavily dependent on regional techniques.

Olive oil extraction is conducted through pressure, centrifugation, and percolation. Nonedible olive oil undergoes a refining process and is blended with edible oils to obtain regular olive oil.[14] Virgin olive oil is obtained under mechanical conditions that do not alter its composition and it is not mixed with other oils. EVOO is the highest quality olive oil and accounts for only 10% of oil produced. It has a free acidity, expressed as oleic acid, of not >0.8%. Experts judge it for taste, mouth feel, and aroma; the oil tends to be most delicate in flavor. Refined olive oil has a free acidity of 0.3%. Regular olive oil, a blend of refined and virgin olive oils has a free acidity of 0.1%.[14]

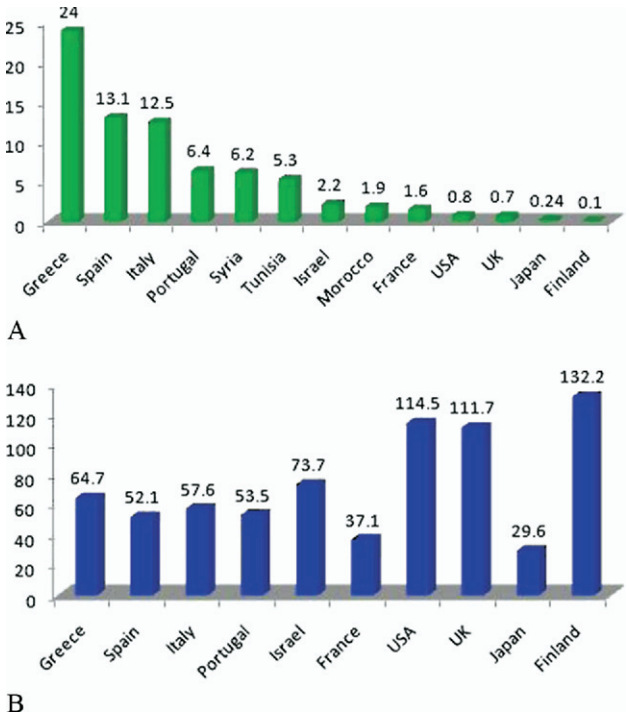

Figure 1. (A) Per capita consumption of olive oil in selected countries (Olive Oil Council Data). (B) Rates of coronary heart disease mortality according to the World Health Organization standard (Cardiovascular Disease Infobase).

The major components of olive oil are known as the saponifiable or glyceride fraction. Glycerols represent >98% of total oil weight and are composed mainly of triacylglycerols (Table 1). Oleic acid makes up 70% to 80% of the fatty acids in olive oil. Minor components are present in about 2% of oil weight and include >230 chemical compounds. These minor components are present almost exclusively in virgin olive oil because the refining process expunges these compounds. Considerable research has centered on extra virgin and virgin olive oil with the belief that these minor components contain important cardiovascular protective effects.

Several components of olive oil have beneficial health effects on the atherosclerotic and thrombotic pathways, which include lipid oxidation, hemostasis, platelet aggregation, coagulation, and fibrinolysis. Oleic acid, a major component, and the polyphenols—tocopherol, hydroxyty-