PISTACHIO RESEARCH SUMMARY

INTRODUCTION

The health benefits of nuts have been demonstrated in many studies. In general, nuts have been shown to have protective heart health benefits and provide a good source of protein and fiber, along with many important vitamins and minerals. While the overall health awareness of nuts is rising, a recent survey reveals that few consumers are aware that pistachios, in particular, have many outstanding nutritional benefits. For example, among nuts pistachios have a high nutrient density; provide an excellent source of copper, manganese and vitamin B6; offer a high amount of total polyphenols antioxidants; and are the only nut to contain significant mounts of lutein and zeaxanthin. Pistachios also offer a high satiety level and as an in-shell snack, have a slower consumption time. The following paper offers a research summary of the outstanding health benefits of pistachios.

PISTACHIO NUTRIENT DENSITY

Table 1 shows the nutrient composition of dry roasted pistachios, based on the National Nutrient Database for Standard Reference, SR 18 (U.S. Dept. of Agriculture, 2005), with biotin and boron values from unpublished research (Deutsch, 1985). Pistachios are an excellent source of vitamin B6, copper, and manganese, containing 20% of the Daily Value (DV) per 28-gram edible portion (about 48 kernels). In addition, pistachios are a good source—10% or more of the DV—of dietary fiber, thiamin, and phosphorus.

In relation to their caloric value (160 calories per ounce), pistachios also have a high nutrient density. Nutrient density, or Index of Nutritional Quality (INQ), is based on a food's nutrient contribution compared to its calorie contribution. It has been suggested that a food can be considered "nutritious" if four nutrients have INQs of 1 or more, or if two nutrients have INQs of 2 or more. (Guthrie & Bagby, 1989; Hansen, Wyse, & Sorenson, 1979)

As **Table 1** illustrates, pistachios are nutrient dense in eight nutrients, with INQs of 2 or more for thiamin, vitamin B6, copper, and manganese; and INQs ranging from 1 to 1.7 for potassium, dietary fiber, phosphorus, and magnesium.

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Table 1. Nutrient Composition and Nutrient Density of Roasted Unsalted Pistachios

Nutrient	Mean Per 100g	Mean Per 28g	% DV	Label Value	Label % DV	INQ [3]	INQ >1
Moisture (g)	1.99	0.56					
Ash (g)	3.05	0.85					
Calories	571.00	159.88		160			
Kilojoules	2391.00	669.48					
Calories from Fat	384.77	107.74		110			
Total Fat (g)	45.97	12.87	19.80%	13	20%		
Saturated Fat (g)	5.56	1.56	7.78%	1.5	8%		
Polyunsaturated Fat (g)	13.90	3.89		4.0			
Monounsaturated Fat (g)	24.22	6.78		7			
Sodium (mg)	10.00	2.80	0.12%	0	0%		
Potassium (mg)	1042.00	291.76	8.34%	290	8%	1.0	X
Total Carbohydrate (g)	27.65	7.74	2.58%	8	3%		
Dietary Fiber (g)	10.30	2.88	11.54%	3	12%	1.4	X
Sugars (g)	7.81	2.19		2			
Protein (g)	21.35	5.98		6			
Vitamin A (IU)	262.00	73.36	1.47%		2%	0.2	
Vitamin C (mg)	2.30	0.64	1.07%		2%	0.1	
Calcium (mg)	110.00	30.80	3.08%		4%	0.4	
Iron (mg)	4.20	1.18	6.53%		6%	0.8	
Vitamin E (IU)	2.88	0.81	2.68%		2%	0.3	
Vitamin K (µg)	13.20	3.70	4.62%		4%	0.6	
Thiamin (mg)	0.84	0.24	15.68%		15%	2.0	X
Riboflavin (mg)	0.16	0.04	2.60%		2%	0.3	
Niacin (mg)	1.43	0.40	2.00%		2%	0.2	
Vitamin B6 (mg)	1.27	0.36	17.84%		20%	2.2	X
Folate (µg)	50.00	14.00	3.50%		4%	0.4	
Panto Acid (mg)	0.51	0.14	1.44%		2%	0.2	
Biotin (mcg)	35.27	9.88	3.29%		4%	0.4	
Phosphorus (mg)	485.00	135.80	13.58%		15%	1.7	X
Magnesium (mg)	120.00	33.60	8.40%		8%	1.1	X
Zinc (mg)	2.30	0.64	4.29%		4%	0.5	
Selenium (µg)	9.30	2.60	3.72%		4%	0.5	
Copper (mg)	1.33	0.37	18.55%		20%	2.3	X
Manganese (mg)	1.28	0.36	17.85%		20%	2.2	X
Chromium (mcg)	24.69	6.91	5.76%		6%	0.7	
Boron (mcg)	561.00	157.08					

PISTACHIO MINERALS

Pistachios are an excellent source of copper and manganese and a good source of phosphorus. From a nutrient density standpoint, pistachios also contain significant amounts of potassium and magnesium in relation to the calorie content.

Copper is essential for a wide range of biochemical processes needed for good health. It is an essential component of many important proteins and enzymes, including those necessary for the proper development of connective tissues in bones and other organs, nerve coverings, and skin pigment. Copper is also important for cardiovascular health. Low copper status has been found in some

studies to increase cholesterol levels, blood pressure, and other cardiovascular problems such as arrhythmia and abnormal electrocardiograms. While copper deficiency is rare, symptoms include skeletal defects and bone demineralization, lack of pigment in skin and hair, and vascular abnormalities. (Institute of Medicine, 2002b; World Health Organization, 1996)

Manganese is an activator and a component of several enzymes and plays an important role in bone formation and in the metabolism of protein, fat, and carbohydrate. Deficiency signs in humans include impaired glucose tolerance, abnormal formation of bone and cartilage, congenital birth defects and retarded growth. (Institute of Medicine, 2002b)

Magnesium works with many enzymes to regulate body temperature, allow nerves and muscles to contract, and synthesize proteins. It is also important in the metabolism of Vitamin D and can directly affect bone cell function. (Institute of Medicine, 1997)

Potassium is the major intracellular cation (positive ion) in the body and is required for the function of all cells. An inadequate intake of potassium is characterized by increased blood pressure, salt sensitivity, risk of kidney stones, and bone turnover. A low intake may also increase the risk of cardiovascular disease and stroke. In its naturally-occurring form in foods, potassium contributes anions (negative ions) that are converted in the body to bicarbonate. Bicarbonate helps maintain a healthy pH (acid/base balance) which, in turn, helps preserve bone minerals that would otherwise be used to maintain the acid/base balance. (Institute of Medicine, 2004)

NO WEIGHT GAIN FROM PISTACHIOS

Because nuts have been shown to be beneficial in lowering cholesterol levels, health professionals felt it was necessary to see if recommending daily nut consumption would lead to weight gain. The National Cholesterol Education Program recommends that maintaining a healthy body weight is also beneficial in maintaining healthy cholesterol levels. Joan Sabate of Loma Linda University conducted nut feeding trials in which free living individuals substituted nuts for 20% of their total calories. Sabate found that, despite the fact that nuts contain fat and are energy-dense foods, nut consumption did not cause an increase in body weight. (Sabate, 2003)

UCLA researcher Karen Edwards put free living patients on a pistachio diet for three weeks, counseling them to substitute pistachios for foods such as candy bars, dairy products, microwave popcorn, buttered popcorn, and potato chips, with pistachios accounting for 20% of total calories. During the pistachio diet subjects kept food records and were weighed on the first three days of week 1 and week 3. Neither body weight nor calorie intake increased as a result of the pistachio diet. (Edwards, Kwaw, Matud, & Kurtz, 1999)

These results for pistachios are consistent with studies of other nuts and body weight. Nut consumption in general is associated with a lower body mass index and has not been shown to cause weight gain. (Sabate, 2003)

Pistachios in the shell may have an added benefit for weight control, slowing down the consumption time while you are shelling the nuts. Studies have shown that the feeling of fullness occurs about twenty minutes after consuming a snack. Slowing down the eating rate allows time for the satiety or fullness factor to catch up.

Satiety factors are related to the composition of the food. Pistachios have a significant amount of protein, fat and dietary fiber, all three of which have been shown to increase the feeling of fullness and the length of time until hunger is felt again. Researchers at Pennsylvania State University recommend eating slowly and relaxing for a few minutes to see if you are still hungry. Barbara Rolls, the lead satiety researcher at Penn State and author of the dieting book Volumetrics, states that snacking is not the problem, but the choice of snack can be. (Rolls & Barnett, 2000) For example, 8 to 10 pistachios are less than 100 calories. This can be enough to curb an appetite and may be just enough to feel full if they eaten slowly and savored for their texture and seasoning. A slow snack of pistachios in the shell may help people maintain their weight by keeping hunger at bay.

TYPES OF FAT

While pistachios are a rich source of dietary fat (13g per serving), 87% of the fat is of the unsaturated type. Monounsaturated fat, mostly as oleic acid, comprises 55% of the fat in pistachios. 32% is polyunsaturated and is primarily linoleic acid. Linoleic acid is an omega-6 essential fatty acid that cannot be synthesized in the body, so adequate intakes are important to health. The Food and Nutrition Board recommends intakes of at least 12g of linoleic acid per day for women and 17g for men. A serving of pistachios provides 3.8g, which

is 22% and 32% of the requirements for men and women, respectively. Both monounsaturated and polyunsaturated fat reduce blood cholesterol levels and lower the risk of heart disease when they replace saturated fats in the diet. (Institute of Medicine, 2002a)

Because no oils are used to roast pistachios, pistachios do not contain trans fat, which is found mainly in partially-hydrogenated oils.

CARDIOVASCULAR HEALTH

Dr. Kocyigit from the Department of Clinical Biochemistry, Medical Faculty in Harran University, Turkey studied the effects of eating pistachios on the risk factors for heart disease. The study took twenty-four healthy men and twenty healthy women with a mean age of 33 and assigned them randomly to either a control diet without nuts or a pistachio-rich regime. The study began after both groups consumed a regular diet without nuts of any kind for one week. Those in the pistachio group replaced 20% of their calorie intake with pistachios for 3 weeks. This was accomplished by cutting down the portion size of fatty foods such as meats and visible fats (oils, margarine and butter.) They consumed about 65 to 75 g of pistachios per day and refrained from eating other nuts during the study.

The pistachio diet lowered total cholesterol (TC) as well as the ratio of TC to HDL. The LDL to HDL ratios also decreased. This study is important because it indicates that pistachios have a protective effect against cardiovascular disease. These results are consistent with evidence about other nuts.

Another protective effect was demonstrated by increased levels of antioxidants in the blood of the pistachio group. Analysis of the diets of both groups showed that the dietary intakes of the pistachio group were higher in monounsaturated fatty acids and dietary fiber, and lower in saturated fats. (Kocyigit, Koylu, & Keles, 2006)

In an overview article from Harvard's Department of Nutrition, Dr. Hu states that not only do nuts have favorable effects on blood lipids, they may also protect against coronary artery disease through other mechanisms, one of which is arginine. Pistachios, like most nuts, are rich in the amino acid arginine, which is a precursor of the endothelium-derived relaxing factor, nitric oxide. Nitric Oxide is a potent vasodilator that can inhibit platelet aggregation and

adhesion. This study proposes that the antiatherogenic effect of nuts might be related to the arginine-nitric oxide pathway. Dr. Hu states that other postulated explanations for the benefits of nuts include their magnesium, copper, folic acid, and fiber content. (Hu, 2003)

Pistachios are also rich in phytosterols (plant sterols with a similar structure to cholesterol). **Table 2** shows the phytosterol content of pistachios. (Phillips, Ruggio, & Ashraf-Khorassani, 2005; U.S. Dept. of Agriculture, 2005) It is believed that these components in pistachios lower the absorption of dietary cholesterol from other foods. (Phillips et al., 2005) Although most feeding trials use high doses of over 2 grams of phytosterols a day, Ostlund's studies showed beneficial effects of reduced cholesterol absorption at lower levels, similar to the levels found in plant-based diets with pistachios. (Ostlund, Racette, & Stenson, 2002)

Table 2. Phytosterols in Dry Roasted Pistachios

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Source	Component	Nut type	mg/100g	mg/28g	Additional Information
USDA SR 18	Total phytosterols	Dry roast	214.00	59.92	
USDA SR 18	Stigmasterol	Dry roast	4.00	1.12	
USDA SR 18	Campesterol	Dry roast	10.00	2.80	
USDA SR 18	Beta-sistosterol	Dry roast	199.00	55.72	
Phillips 2005 J Agric Food Chem	Total phytosterols	Dry roast	279.20	78.18	Same USDA sampling
Phillips 2005 J Agric Food Chem	Stigmasterol	Dry roast	2.30	0.64	but different composites
Phillips 2005 J Agric Food Chem	Campesterol	Dry roast	10.10	2.83	
Phillips 2005 J Agric Food Chem	Beta-sistosterol	Dry roast	209.80	58.74	
Phillips 2005 J Agric Food Chem	Delta-avenasterol	Dry roast	26.20	7.34	
Phillips 2005 J Agric Food Chem	Sisostanol	Dry roast	1.20	0.34	
Phillips 2005 J Agric Food Chem	Campestanol	Dry roast	5.00	1.40	
Phillips 2005 J Agric Food Chem	Other sterols	Dry roast	24.60	6.89	
Phillips 2005 J Agric Food Chem	Unknown sterol A	Dry roast	5.80	1.62	
Phillips 2005 J Agric Food Chem	Unknown sterol B	Dry roast	6.20	1.74	
Phillips 2005 J Agric Food Chem	Unknown sterol C	Dry roast	12.60	3.53	C is tentatively ID'd as poriferasta-7,25-dienol

DIABETES

Pistachios are naturally low in carbohydrates and rich in monounsaturated fatty acids (MUFA). This makes them a perfect snack for diabetics who wish to follow the suggested guidelines to replace carbohydrates and saturated fat with MUFA in the diet. Clinical trials have shown that such diets help to maintain blood sugar and insulin levels and reduce risk factors for heart disease, a consequence of diabetes that accounts for 80% of diabetic deaths.

Scientists have debated for years whether low-fat, high-carbohydrate diets or moderately high-fat, MUFA-rich diets are preferable in attaining the goal of metabolic control. While both approaches can have positive effects on metabo-

lism, MUFA-rich foods of plant origin, such as pistachios, also contain dietary fiber, phytosterols, and antioxidants such as phenols and alpha tocopherol. These components confer a wide variety of cardiovascular benefits which include glycemic control, improved lipid profiles, reduced LDL oxidation, and improved endothelial function. A MUFA-rich diet is also generally more palatable and easier to maintain than a low fat diet. (Jenkins et al., 2003; Kris-Etherton, 1999; Ros, 2003)

GALLSTONES

Tsai and coworkers studied the 20-year records of 80,718 women from the Nurses' Health Study, 7,831 of whom had undergone surgical removal of the gall bladder due to gallstones. Researchers found a significant 25% reduction in gallstone disease among those who consumed 5 or more ounces of nuts per week compared to women who ate less than 1 ounce of nuts per month. The monounsaturated and polyunsaturated fats in nuts may partially account for the reduced risk by inhibiting cholelithiasis, the formation of cholesterol gallstones. However, when researchers controlled for the intake of specific fatty acids in their statistical analysis, nut consumption still showed a significant protective effect. Other bioactive components of nuts such as dietary fiber, phytosterols, and magnesium may contribute to this effect by lowering cholesterol absorption and reducing insulin sensitivity. (Tsai, Leitzmann, Hu, Willett, & Giovannucci, 2004)

B6 AND OTHER B VITAMINS

Pistachios are an excellent source of vitamin B6, containing as much as beef liver, which is often touted as an "especially rich source" of this vitamin. Per serving, pistachios provide 20% of the DV. Vitamin B6 is required for a wide range of biochemical reactions in the body. For example, it is needed for over 100 enzymes involved in protein metabolism. Vitamin B6 is required for the efficient functioning of the immune system, conversion of the amino acid tryptophan to niacin, red blood cell metabolism and hemoglobin production, and synthesis of neurotransmitters such as serotonin and dopamine that are necessary for nerve cell communication.

Vitamin B6, folate, and, to a lesser extent, vitamin B12 have been shown to reduce elevated levels of homocysteine, believed to be a risk factor for cardiovascular disease. Inadequate intakes of vitamin B6 have been reported to impair platelet function and clotting mechanisms, effects that may be related to elevated homocysteine. (Institute of Medicine, 1998)

Vitamin B6 also helps to maintain normal blood sugar levels when caloric intake is low, converting stored carbohydrate and other nutrients to glucose. (NIH Office of Dietary Supplements, 2006))

Vitamin B6 may have particular benefits for women's health as well. Decreased vitamin B6 status has been reported in a number of studies of women taking high-dose oral contraceptives. (Institute of Medicine, 1998) It is possible that additional vitamin B6 may benefit women on birth control pills and hormone replacement therapy. Vitamin B6 may also be useful in alleviating the symptoms of premenstrual syndrome (PMS). (PDRhealth, 2006) It is estimated that 10 to 15% of women through age 50 and 25-50% of older or pregnant women are not consuming the recommended amount of vitamin B6. (Institute of Medicine, 1998)

In addition to vitamin B6, pistachios are a good source of thiamin (15% DV) and contain lesser amounts of other B vitamins, such as folate and biotin at 4% DV, and riboflavin, niacin, and pantothenic acid at 2% DV. These B vitamins play many essential roles in the conversion of carbohydrates, proteins, and fats into energy.

DIETARY FIBER

Pistachios are a good source of dietary fiber and are among the highest fiber nuts, providing 12% of the DV per serving. Dietary fiber benefits the digestive tract by absorbing water, softening the stool, and preventing constipation. These effects can help prevent hemorrhoids, varicose veins, hiatal hernias, and diverticulosis. Clinical trials have shown that dietary fiber can also help to control blood sugar, lower serum cholesterol, and possibly promote weight control and reduce the risk of some types of cancer. The U.S. Dietary Guidelines Committee recommends a dietary fiber intake of about 14 grams per 1000 calories, but consumption studies have indicated that Americans typically consume only half of the recommended amount. (Institute of Medicine, 2002a; National Research Council, 1989; U.S. Dept. of Health and Human Services & U.S. Dept. of Agriculture, 2005)

CAROTENOIDS

The carotenoid content of pistachios is given in **Table 3**. (U.S. Dept. of Agriculture, 2005) Pistachios contain about 2% DV of vitamin A in the form of beta carotene. In addition, pistachios are the only nuts that contain a significant

amount of lutein and zeaxanthin. These two carotenoids are closely related and are usually reported as "lutein + zeaxanthin." Pistachios contain 337 mcg mg of lutein + zeaxanthin per serving, about 13 times as much as the next highest nut, hazelnuts, which contain only 26 mcg. (U.S. Dept. of Agriculture, 2005)

Although lutein + zeaxanthin do not have vitamin A activity, the intake of these carotenoids has been associated with a reduced risk of age-related macular degeneration (AMD). AMD is the most common cause of irreversible blindness in Americans over 65. The macula, located in the center of the retina, functions to maintain acute central vision. Of all the circulating carotenoids in the body, only lutein and zeaxanthin are found in the macula. In a large, multicenter, case-control study by Seddon et al. (1994), persons with the highest lutein + zeaxanthin intake showed a 60% lower risk for AMD than those with the lowest intakes. (Institute of Medicine, 2000; Seddon et al., 1994) Recommended intakes of lutein + zeaxanthin have not been established, but intakes of 7,000-12,000 mcg per day have been associated with a reduced risk of AMD. (PDRhealth, 2006)

Table 3. Carotenoids and Tocopherols in Dry Roasted Pistachios

	Nutrient	Mean per 100g	Mean per 28g
Carotenoids	Beta carotene (mcg)	157	44
	Lutein + Zeaxanthin (mcg)	1205	337
Tocopherols	Alpha tocopherol (mg)	1.93	0.54
	Beta tocopherol (mg)	0.14	0.04
	Gamma tocopherol (mg)	22.45	6.29
	Delta tocopherol (mg)	0.73	0.20

TOTAL PHENOLS AND ANTIOXIDANT CAPACITY

Oxidative stress is implicated in many diseases including cancer, heart disease, Alzheimer's, and Parkinson's disease and is also involved in the aging process. Dietary antioxidants help to reduce oxidative damage to molecules such as proteins, lipids, and DNA.

Table 4 shows the total phenolic content and antioxidant capacity of pistachios. (Kornsteiner, Wagner, & Elmadfa, 2006; Wu et al., 2004) Phenolic compounds are believed to account for a major portion of the antioxidant capacity of many

plant foods. USDA researchers tested 100 common foods purchased in the United States, including 7 composite samples of pistachios, for total phenolic content (Folin-Ciocalteu method) and for hydrophilic and lipophilic antioxidant capacity (H-ORAC and L-ORAC). (Wu et al., 2004)

Table 4. Pistachio total phenolics and antioxidant capacity

Source	What was tested	Per 100g	Per 28g	Units
Kornsteiner 2006 Food Chem	Total Phenols (Folin Ciocalteu)	867	242.76	mg GAE
Wu 2004 J Ag Fd Chem/JFCA	Total Phenols (Folin Ciocalteu)	1657	463.96	mg GAE
Wu 2004 J Ag Fd Chem/JFCA	Total Antiox. Capacity (L-ORAC + H-ORAC)	7980	2234.4	umol TE

The average phenolic content of pistachios was found to be 464 mg GAE (Gallic Acid Equivalents) per 28 grams. Among the 10 nuts tested, only pecans outranked pistachios in total phenols. Walnuts were nearly as high as pistachios, but all other nuts were much lower. Kornsteiner found a lower level of total phenols in pistachios, which may be due to a natural variation in phenolic content or perhaps the source of the nuts, which were purchased in Austria and Greece. (Kornsteiner et al., 2006)

Total antioxidant capacity (TAC) was calculated by USDA researchers as the sum of H-ORAC and L-ORAC, expressed as micromoles of Trolox equivalents (μmol TE). The mean TAC for pistachios was 2234 μmol TE/28g. In these tests, pistachios ranked 4th in TAC after pecans, walnuts, and hazelnuts. When the 100 foods were categorized into four groups according to their antioxidant capacities, pistachios were in the highest group for both H-ORAC and L-ORAC. (Wu et al., 2004)

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